THE GULICK HYGIENE SERIES

BY

LUTHER HALSEY GULICK, M.D.

THE GULICK HYGIENE SERIES

BOOK FIVE

CONTROL OF BODY AND MIND

BY

FRANCES GULICK JEWETT

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EDITOR'S NOTE

In four respects we have attempted in this series to do what, so far as we know, has not been attempted before.

1. We have endeavored to present to children a series of texts in which the central theme shall be hygiene. The current school text-books treat of physiology and anatomy primarily. The reason we have placed this special emphasis on hygiene is that we believe the first purpose of such study in the elementary schools should be to influence children definitely towards more intelligent and better habits of living. We also believe that the study of physiology and anatomy as such is of little use or even intelligibility until the high-school or even the college age.

2. It is the purpose of the series to treat each subject in a purely scientific, as distinguished from a philosophical manner; for instance, as far as possible genuine experiments by the child are urged, and the results of such tests are given. The child's own action, experience, and observation are constantly drawn upon, so much so that the blunt facts of actual experience, rather than those of any philosophical argument, constitute the plea.

3. We have presented a new point of view in each volume. The body has been viewed from the standpoint of

a. General health,
b. Accidents and emergencies,
c. Social relations,
d. Physical efficiency,
e. Mental and moral control.

Under each of these rubrics it has been necessary to discuss many of the same sets of facts, but they have new meaning because of their relations. In the first volume (*Good Health*) alcohol is discussed in its general relations to health; in the second (*Emergencies*) as a factor in injuries and accidents; in the third (*Town and City*) in its relation to the community as a whole; in the fourth (*The Body*) in its effects on the bodily organs; while in the fifth (*Control*) it is discussed in its relations to character and morals. This mode of treating a subject I believe to be a fundamental necessity to good pedagogy. The teaching of essentially the same physiology with merely increased details from year to year seems to account in some measure for the distaste with which it is so often regarded by both teachers and pupils.

4. These little volumes have been prepared with the same kind of utilization of original works as if they had been intended for adult scientific workers.

LUTHER HALSEY GULICK

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INTRODUCTION

This book deals with the elementary facts of the nervous system and with the underlying principles which govern man's mental operations. It shows what nerves are, how they do their work, what gives them vigor, what does them harm, how they may be taught lessons, how they form habits, how their power may be increased and how it may be lost. In other words, *Control* tries to give in readable form the fundamental facts about that part of the human system which influences man's mental and moral destiny. Through the dramatic interrelation of muscle and neuron it has indeed been possible to show that mind and body depend on each other.

As in the previous volumes of the series, so here, the chapters concern themselves with clearly demonstrated scientific facts, not with theories; with data, not conclusions. Dogmatic assertion and broad generalizations have been avoided, the object being so to inform the reader that he shall be led to draw conclusions for himself from the facts given.

Emphasis is laid on the care and cultivation of the special senses; on the relation of health to efficiency,

mental clearness, and memory; on the influence which worry, fear, anger, hope, and joy exert over circulation, respiration, and digestion; on the power which alcohol and narcotics have to damage the nervous system and to destroy character. Moreover, in every instance, function rather than nerve anatomy receives the larger treatment. This is involved in the nature of the topics which have been discussed.

In point of fact this book has been written with the conviction that such subjects as attention, choice, will power, habit, and character are not too abstract to be both interesting and inspiring to young people. It assumes that the reasoning power of school children is strong enough to recognize the value of scientific discoveries, keen enough to see the force of their application, and so logical as to make the application closely personal. The ambition of the book is to be something more than a series of chapters to be recited on stated days. It aims to be a series of steps which shall lead to the development of individual character.

Not merely is it the purpose of this series to teach scientific facts, but also, and especially, so to arrange and present these facts that, from page to page, they shall hold the reader's close attention and inspire personal loyalty to the laws of health. To further this purpose, side headings have intentionally been omitted, so that each chapter may make its first appeal to the

reader as a unified whole rather than as a series of disjointed fragments. While the disadvantages of side headings in interrupting the continuity of thought have been avoided, all their advantages are secured through the questions at the end of the volume, which, in a different form, answer the same purpose.

In showing how we may progressively modify our lives in directions of increased efficiency and health the best works of the leading psychologists and neurologists have been pressed into service. And to reënforce their instruction many illustrations have been chosen from among those already in wide use. Others, more technical, have been secured through the courtesy of the publishers. Special mention should be made of such as have been borrowed from *Fatigue*[1] and *Fear*[2] by Dr. Mosso; from *Nervous and Mental Hygiene*[3] by Dr. Forel; and from *Recent Developments in Massage* by Dr. Graham. *Alcohol and the Human Body*,[4] by Sir Victor Horsley and Mary D. Sturge, has been drawn on for illustrations that show the effect of alcohol on nerve substance.

F. G. J.

[1] *Fatigue*, by Angelo Mosso. G. P. Putnam's Sons.

[2] *Fear*, by Angelo Mosso. G. P. Putnam's Sons.

[3] *Nervous and Mental Hygiene*, by August Forel. G. P. Putnam's Sons.

[4] *Alcohol and the Human Body*, by Sir Victor Horsley and Mary D. Sturge. Macmillan & Company, Limited.

CONTROL OF BODY AND MIND

CHAPTER I

MOTION AND SENSATION

My friend was a football player on the college team, and an all-round athlete. But when they took him from the wrecked train he was paralyzed from thigh to heel. He could not move a muscle in either leg; he could not bend his knees, and, although he used all the will power he had, he could not pull a single toe either up or down.

Fortunately, however, he could use his arms as well as ever. His mind, also, was perfectly clear, and he understood the doctor when he said: "Two or three of the lower vertebræ of your backbone are somewhat crushed; they are crowding against the spinal cord which runs through them, but if we can get the pressure lifted, you will be able to move your legs as well as ever."

A few days later, even while the legs were still motionless, they became wonderfully sensitive; so much so, that even the weight of the bedclothes pained them, and

if the doctor or the nurse so much as touched them through necessity, it took all the bravery the man could muster to keep from showing what he suffered.

After several weeks the pain grew less. After still other weeks there came what the man called "the happiest moment" of his life. "Look!" he called to his nurse; "look, I can move my toe!"

There was steady gain after that. Toes, feet, legs — he could move them all at last, and in the course of months he learned to walk again; but always throughout life one foot will continue to drag a trifle when he walks, for a bit of crushed bone still presses on the part of the spinal cord which controls that foot.

As this man recovered, he met another man in worse condition than himself. He, too, had had a broken back. But in his case not only were his legs motionless but he could feel nothing in them. He only knew he was touched or pinched, pricked or scratched when he fastened his eyes on the spot and saw that something was being done there.

This lack of feeling reached as far up as his waist. And it was so complete that when, at one time, the doctors needed to cut through his skin below the waist, and then needed to sew the cut up again, they gave him neither cocaine to deaden pain, nor ether to put him to sleep. They did their work thoroughly, and he might have watched them even as they did it, for from first

to last not a twinge of pain reached him. He could not walk but he was very comfortable in his wheel chair.

Cases of this sort are so raie that most of us know nothing about them. There are examples enough on record, however, to fill many pages of medical books, and each separate case shows that whenever the body fails to move or to feel or to do its own work in its own way, nerves are at fault somewhere — nerves that bind muscles and mind so closely together that when one suffers the other suffers too.

Nerves control the Power of Each

At this point I glance up from my writing and see our great yellow cat with soft fur and quiet eyes sitting on the window sill watching a fly. Queerly enough, he does not even lift a paw to strike it. Instead, as the fly runs along on the edge of the window frame, the watching cat cocks his head to one side and seems to be studying his small neighbor as if he himself were a scientist, as if he were anxious to know what the secret of the machinery is

that makes the slim legs move so fast and pulls the wings of gauze up and down.

I am wiser than the cat, and I know that all the power of cat and fly and man lies hidden in the nervous system which controls the life of each. I know that nerve fibers carry messages to and fro; that these fibers look like slender white threads; that they run from head to spinal cord, from cord to muscle, then from muscle up again to cord and head; that, just under the skin, they cover the body in a close network, and that it is through their aid that living beings think and feel and move.

I have also learned that human nerves and cat nerves are very much alike, and that men and women, boys and girls, and animals of every size and shape are protected and actually kept alive by the pleasant and the unpleasant messages and commands which travel up and down and crosswise on these sensitive telegraph wires.

If a cat felt no unpleasant sensation when he needed food, he would never bestir himself from a comfortable nap for the sake of eating. If a mouse felt no unpleasant sensation when the claws of a hungry cat were hooked into his skin to seize him, he might allow himself to be caught and eaten without a struggle. If human beings felt no discomfort in the coldest weather, they might carelessly let themselves be frozen to death.

So it is on every side. All along the way we go, our sensations are our best protectors. Indeed, during each

day of our lives, our animal kindred and we ourselves travel through life over a road that is guarded on either side by what might seem to be a hedge of nerve warnings called sensations. The sensations themselves are of many kinds — hunger and thirst, cold and heat, headache, toothache, stomach ache — ills of a thousand different sorts. But through each separate one we learn at last that by giving heed to our sensations — to those that are disagreeable as well as to those that are agreeable — we preserve our health and find the pathway of life very pleasant.

CHAPTER II

SERVICE FROM THE CEREBRUM

In a battle on the river Nile a certain British captain was hit on the head by a bullet at the moment when he was shouting a command to his soldiers.

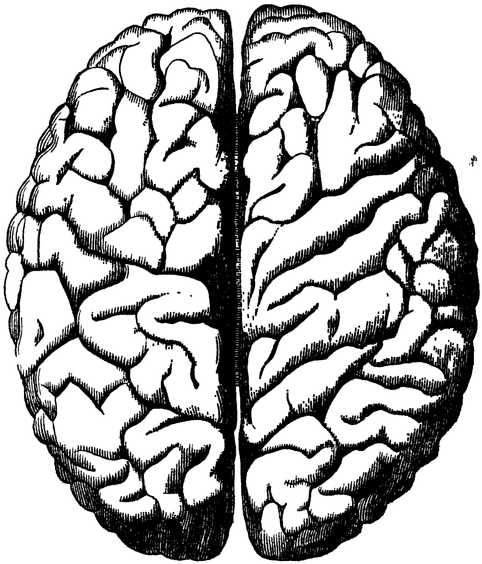
He became unconscious at once, and for fifteen months afterwards stayed in bed in a hospital, unable to speak, apparently asleep.

There seemed to be no hope for him until a skilled surgeon determined to cut through the skull and see what was interfering with the work of the brain. And there he found it! Jagged edges of bone were pressing into the soft substance underneath.

He smoothed off the edges, cut away bits of bone, lightened the pressure, and no sooner was the rough weight lifted than the wounded man came to his senses, rose from his bed, and finished giving the command which he had begun to give fifteen months before. He himself had no idea that anything had interrupted him, and he was astonished enough to find himself indoors with doctors instead of out of doors on the battleship, with soldiers about him.

There we have it then: we have come upon the region of the brain that is most vitally connected with our thinking and with our power to give commands.

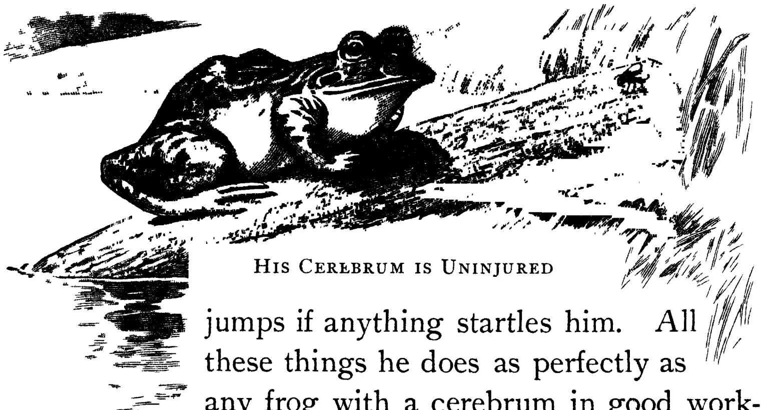
This constantly active and most important part of the nervous system lies just under the skull. It is the largest division of the brain, is separated into two halves called hemispheres, and the two together make up what is called the cerebrum.



THE HEMISPHERES OF MAN'S CEREBRUM, THE CENTER OF CONTROL

Certain small animals can live and grow with almost no suggestion of a brain. With a frog, however, affairs are more serious. When by any accident in his out-of-door life his cerebrum is damaged in such a way as to make it useless, he loses his wits entirely. His cerebrum is indeed his thinking cap, and when it cannot do its work the frog himself is not able to start off on an enterprise of any sort. On the contrary, he sits for hours and for days without moving. He makes no plans for any

adventure. He does nothing new and original. It is true that if he is laid on his back, he turns over and puts himself right side up again; if he is thrown into water, he swims to land and crawls out upon it; if anything is in his way, he goes round about to avoid it; he



His Cerebrum is Uninjured

jumps if anything startles him. All these things he does as perfectly as any frog with a cerebrum in good working order; but more than this he does not do.

It has happened sometimes that, in their hunting, men have injured no part of a pigeon except its cerebrum. In such cases the bird has not suffered conscious pain. And yet, from the moment of the accident onward, there has been a change in the life it leads. From being active, it has become inactive; from being bright, it has become dull.

Toss such a bird into the air and it will fly; set it upon a perch and it will hold itself in place; but it makes no move to fly on its own behalf. Instead of that,

it sits by the hour and the day with head pulled down between its shoulders, with eyes shut and feathers standing up a little. Once in a while it may open its eyes, poke its beak through its feathers for a moment, and stretch its neck; but soon it is back in its old position, as dull and lifeless as possible. It does not even know enough to feed itself. Such birds are willing to swallow, however, if they are fed, so that they may live on quietly for months; but it is an inactive life.

Dogs, however, being more intelligent, lose even more than pigeons do when the cerebrum is gone.

Dr. Howell, in his great physiology, tells of such a case. The dog met with misfortune, lost his cerebrum, and led a singular life ever afterwards. Those who were studying the case kept him alive a year and a half, and certainly he did not suffer actual pain. Nevertheless he did not know enough to feed himself; he did not even recognize his food when he saw it; he showed no pleasure when caressed nor any fear when threatened. Not a trick that he had ever learned did he now remember. And as for burying bones for future use, there was no thought of such a thing. Indeed, from the moment he lost his cerebrum until he died he seemed to do no thinking whatever. Memory was so entirely gone that he recalled nothing that he had ever learned. Formerly he had been a clever and sprightly dog — remembering old tricks, learning new ones, stealing bones and burying

them, frightening cats, loving his friends and fighting his foes; but from the moment he lost his cerebrum all was changed.

In man the cerebrum is even more important. He may lose part of it through disease or accident and still be able to live and think; but if he loses the whole of it, he dies. If it is injured, he suffers in various ways.

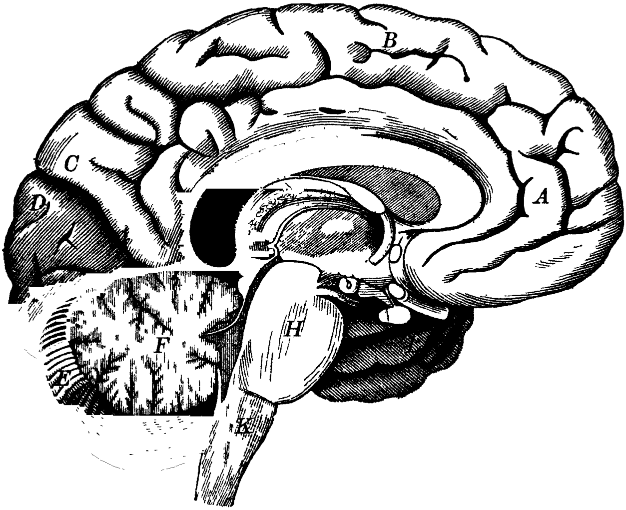
If you ever have a chance, take in your hands a human brain that has been preserved in alcohol, and let a doctor describe it to you. First of all, however, you will notice that the substance itself looks like nothing so much as a neatly folded, closely packed mass of gray putty — so lifeless and so uninteresting that you may feel like exclaiming:

"Is this the great commander in chief of the body of man? Is this queer-looking stuff the basis of all my thinking and my feeling!"

But let the doctor hold it and explain it to you, part by part. Watch his eyes; listen to his voice as he does it; for they will tell you that, to him, this lifeless mass is interesting in every smallest division. He will press one part away from another at the surface, and you will see that although each can be separated slightly from its neighbor, still all are firmly held together at the center. In his enthusiasm the doctor may also mention one long scientific name after another — each belonging to its own special brain division. But if he is wise he

will tell you that for the present you are to remember but two of the names, — Cerebrum and Cerebellum.

He will probably mention them in that order, for larger and higher up is the cerebrum, a soft gray cap it seems to be, folded closely in deep creases, overlapping



A CUT THROUGH THE BRAIN

A, *B*, *C*, *D*, *L*, show folds in the cerebrum, *E*, *F*, show the gray and white of the cerebellum, *K*, *H*, show the upper divisions of the spinal cord

everything below it. Nevertheless the cerebellum is in sight just beneath, at the back of the head. This, too, is folded and wrinkled and gray.

It may be that you will ask some questions about these deep creases in both cerebrum and cerebellum; and it may be that the doctor will flash back his swift

answer, "The more wrinkles, the more wits," for that states the case concisely. "But what good do the creases do?" you ask again. "Give more surface for the gray stuff to be spread over," comes back the answer quick and positive. And that answer leads the doctor up to the point of his greatest enthusiasm — the gray and white substance of the brain.

Gray is all you have seen thus far, for it bends in and out with every fold and crease as if the whole substance of the brain were solid gray. "But look here," exclaims the doctor, as he presses open a deep cut which he has made with his knife through the gray cap; "see how little gray there really is; only an outside layer about an eighth of an inch thick, and thinner than that in spots. But every thought you have, every pain you feel, every plan you make, every hope that thrills you, every purpose and ambition of your life is intimately connected with this thin gray layer that covers the white substance below it."

While you are thinking this over in amazement, he will probably go on to say that the injury or disease of any part of that gray layer of the brain may rob you of one sense or another, or even destroy your brain power in the very direction where you thought you were strongest. You will then recall the captain and his interrupted command, and you will understand at once that he happened to be injured in just that

part of the brain which had charge of his power to give commands.

"If this particular brain had been injured here," the doctor will say, pointing to a certain spot on the gray surface, "its owner would not have been able to recognize anything that the eye looked at. And this is the worst sort of blindness, for when the sight center of the cerebrum is gone a man cannot so much as remember what seeing was like."

Accidents to the brain have taught some of these facts, diseases of the brain have taught others; while the study of the brains of animals has let in a flood of light on the whole subject. So that at the present time scientists know that a definite part of the gray layer is active for each separate sensation and for the power to move each separate part of the body.

This layer is called the cortex, and cortex means bark. It is clear then that the gray bark that covers both cerebrum and cerebellum is the most precious part of the human body. For this reason it needs a stout protection, and it gets it in the firmly knit, sturdy skull which surrounds it.

Instead of being a snug fit in its case, there is a little space filled with liquid, which separates the brain from the skull.

The explanation of the white and gray substance of the brain is given at the close of the tenth chapter.

CHAPTER III

BERTINO'S BRAIN

The work which Dr. Beaumont did in getting an inside view of the stomach of Alexis St. Martin was wonderful enough, surely, but Dr. Mosso[1] did something even more wonderful. He followed the working of the brain itself through a hole in the skull.

His first chance to do this was with a poor woman named Margherita. She had a disease which destroyed certain bones of her body. Finally it attacked the bones of the forehead just above the nose and left a round hole through which any scientist was glad to look. This was the chance of a lifetime, for the woman was in a hospital, and Dr. Mosso could follow her case from day to day. Looking through that hole he saw the uncovered brain and noticed that it throbbed and pulsed like the living thing it really was. To test it carefully he invented a delicate instrument which he could slip through the hole in such a way that it rested on the membranes that cover the brain. The machine was also able to keep its own record of the activity of the brain, for a

[1] Professor of Physiology in the University of Turin, Italy.

pencil was connected with it which drew longer or shorter marks on a sheet of paper, according as the brain was active or quiet.

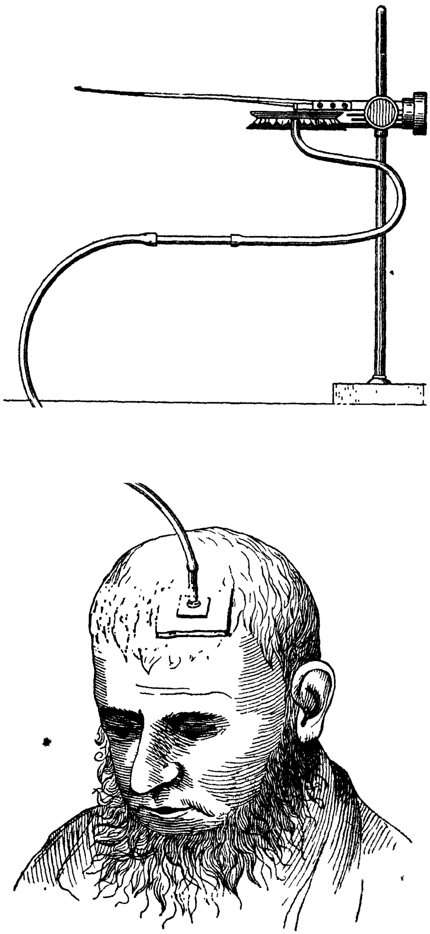
One day as Dr. Mosso sat near the woman, watching the machine which he had slipped into place, he noticed a sudden change in the record. Quite abruptly it began to draw lines that showed a stronger pulse, while at the same time the brain grew larger.

This seemed strange, for there had been no change in anything in the room, and the woman said she felt as well as usual. Dr. Mosso then asked her what she had just been thinking about, and this brought the explanation. She said that as she had been looking at the hospital bookcase in an absent-minded way, she suddenly saw a human skull between the books, and that this frightened her because it reminded her of her own troubles. "Fright, then," thought Dr. Mosso, "drives the blood to the brain."

Soon after this a scab grew over the exposed brain surface so that tests became impossible.

Two years later, however, Dr. Mosso had an opportunity to experiment with another brain; this one belonged to the head of a vigorous mountaineer. In July, 1877, the man was at work on a church, when a brick was accidently dropped by another man on the roof. It hit Bertino on the head and left him unconscious for an hour.

When he came to himself there was a hole "as big as a shilling in the middle of his forehead," but his mind was as clear as ever. By careful work the fragments of broken bone were picked away one by one, and through the opening the doctors saw the brain steadily throbbing. This was possible because of the open space between the brain itself and the skull which protects it.



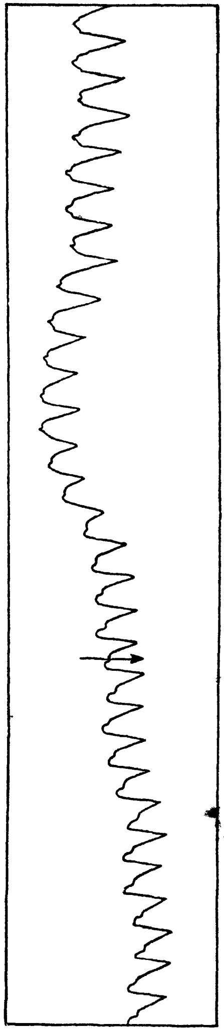
TESTING BERTINO'S BRAIN

In the course of time the machine and the doctor began their records and their observations. Sometimes the pulse lines were low and broad; sometimes they were higher and sharper; almost never were there any two precisely alike.

When the man went to sleep with the

machine still writing its record the undulations were lower and slower, and at times there were long stretches between them, as if all the ripples were being smoothed to quietness. When this point was reached Bertino was always asleep, no thinking was going on. But with the slightest noise—the moving of a chair, the steps of a passer-by, the striking of the clock in the hospital—there was an instant change. In fact, any sound whatever left its record. At such times Bertino was not always wakened, but his brain proved that it took note of the disturbance, for instantly the line of the writing was disturbed. It traveled higher as well as lower.

On a special occasion Dr. Mosso let Bertino sleep soundly for an hour and a half. He then stepped towards his pillow on tiptoe, and at just the point where the arrow appears in the tracing he said very gently, "Bertino." The man neither stirred nor made any answer. He slept



Record made by the Apparatus while Bertino Slept

on; but notice the record. See the increased height of the marks as Dr. Mosso stepped across to Bertino, then see the sudden rise after that. The man did not waken, but his brain had become more active.

At other times, for the sake of testing the brain when it was awake, Dr. Mosso spoke sharply to Bertino. And always when he did it the throbbing increased just there, so that the record stretched upward six and seven times higher than before. Indeed, the blood vessels were now so enlarged with blood that the brain itself was larger. Scientists learned several lessons from these and other experiments.

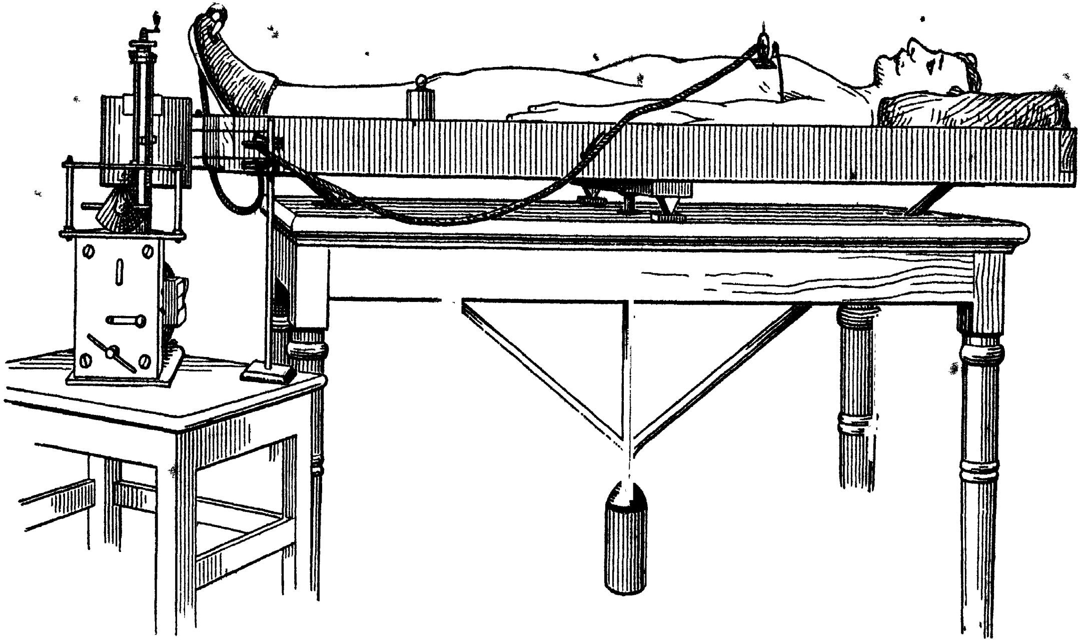
1. According as the brain is more or less active, so also is more or less blood sent up to it.

2. During sleep the less blood there is in the brain the more soundly do we sleep.

3. The brain responds to outside disturbance even when the owner of it does not waken.

4. When an outside disturbance causes the brain to be active so that more blood goes to it the sleeper does not rest so completely as he did when his brain received less blood.

This last point controls the action of mothers who are careful of their sleeping children, of doctors who wish to save their patients, and even of cities that are anxious for the welfare of their citizens. In each case the effort is to secure as much quiet as possible for those who sleep.



A Balance Board

When he thinks hard the board will sink at the head and rise at the feet. When he sleeps it will tip the other way — head up, feet down

Even now men and women in different parts of the country are fighting for freedom from unnecessary noises at night. Doctors claim that these noises are the cause of certain brain disorders, and that even healthy people suffer if they sleep in noisy places. No doubt the time will come when railroad trains and steamboats will pass by more quietly at night.

Dr. Mosso not only counted the pulse of Bertino's brain and compelled it to make its own record but he also did something that seems like weighing thought. He invented a machine which shifts its balance according as the person who lies upon it is resting his brain or using it. If a child on this balance begins to think, the machine dips down at the head, showing that suddenly that part is heavier. We know the reason. Thinking involves brain exercise, exercise draws blood to the brain, and blood is heavy enough to be weighed.

But let the same child go to sleep on the same machine and the brain will grow lighter and lighter as thinking ceases, until the head is up again and the feet down. In this way, with thought and sleep alternating, the body might keep up a gentle seesaw.

This machine is so very sensitive that even while the child is asleep, if a door is opened or a chair moved, at once the head sinks a trifle and the feet rise, for the balance of the body has changed. If a student resting on it, being wide awake, begins to think out a hard mathematical

problem or tries to study Greek, the machine tells the story of the blood that is pouring into the brain.

All this helps explain points that we ourselves have noticed. Why do I grow pale when I am frightened? Simply because the blood has gone elsewhere, robbing every tip end of the blood vessels of my face. No wonder I am pale! For the same reason my hands and feet are cold when I am frightened. The blood has rushed to the centers. Hands and feet are left without that which keeps them warm. This also explains why soaking the feet in hot water relieves certain kinds of headache. It draws blood away from the crowded blood vessels of the brain.

Because this constantly moving blood supplies all the nourishment the brain will ever get, because it is rich or poor as nerve food in proportion as we have treated it with wisdom or with folly, our responsibility for the vigor of our brain becomes very great. Those of us who treat it best are apt to be the ones who bear in mind the following facts and act upon them:

1. Blood is the food of the brain.

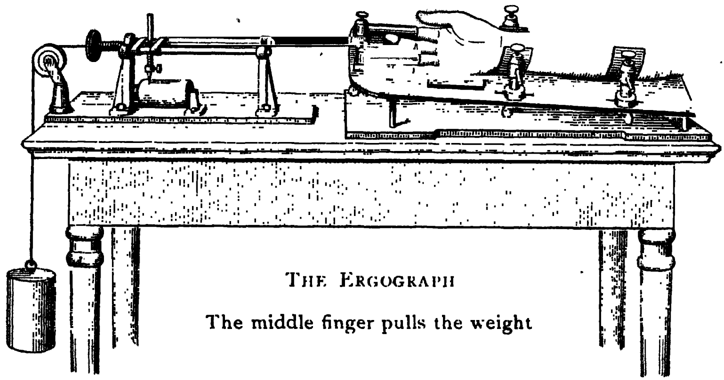
2. The quality of the blood is improved by keeping it supplied with all the oxygen it can use. (Good ventilation and wholesome exercise are in point here.)

3. The food we eat and the way we eat it (see *The Body at Work*) improves or weakens the value of the blood. The laws of eating too much and eating when we are very tired apply just here.

CHAPTER IV

TIRED BRAIN AFFECTING MUSCLE POWER

When Professor Mosso wished to find out whether a tired brain makes any difference with a man's power to work hard with his muscles; he asked two of his friends



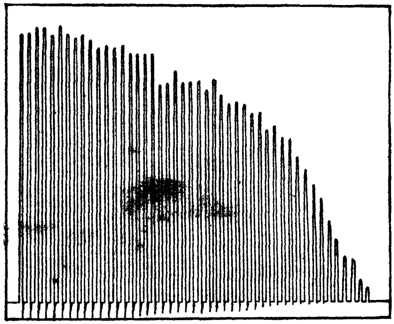
THE ERGOGRAPH

The middle finger pulls the weight

to use a finger machine which he had invented, and which he called an ergograph.

The machine held the hand, wrist, and arm in a firm position, but it left the middle finger free for use. To this was fastened a string which was tied to a six and a half pound weight at the other end. The finger was to raise that weight as high as it could once every two

seconds, and to continue the work as long as possible. As this went on, a pencil which was fastened to the string drew a separate dark line on a piece of paper for every pull that the finger made, and these pencil marks showed the number of times the weight was raised and the height of each raising.

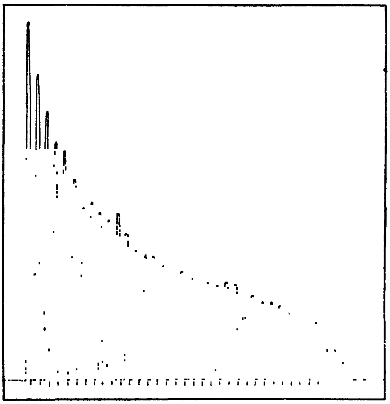


RECORD MADE BY PROFESSOR ADUCCO

Dr. Aducco and Dr. Maggiora were the friends who lent their hands to Dr. Mosso for the finger-pulling contest. That is, each consented to have his middle finger tested. The tests were to be made under all sorts of conditions, when the brain was rested and when it was tired, when it was excited and when it was calm, when the men were well and happy and when they were ill and unhappy.

The first record shows the tracing which Dr. Aducco's finger made when he himself was in a rested, healthy condition. Notice the curve. It is rather round and full and ends abruptly. Compare this with the next—Dr. Maggiora's record. Here the abrupt change is in the beginning, so that we have a hollowed-out curve and a tapering end. Such a difference is what is called the "fatigue curve" of the two records; but each finger

had tried to do precisely the work which the other had done. Each had raised the weight as high as it could once every two seconds, and had kept doing this as long as it could. Moreover, each man was healthy and each was twenty-eight years old. They had the same kind of occupation, lived the same sort of lives, and the one was as busy every day as the other. In all these things they were alike, yet the wonderful ergograph betrayed at least one vital difference between them — their fingers could not pull the same curve.



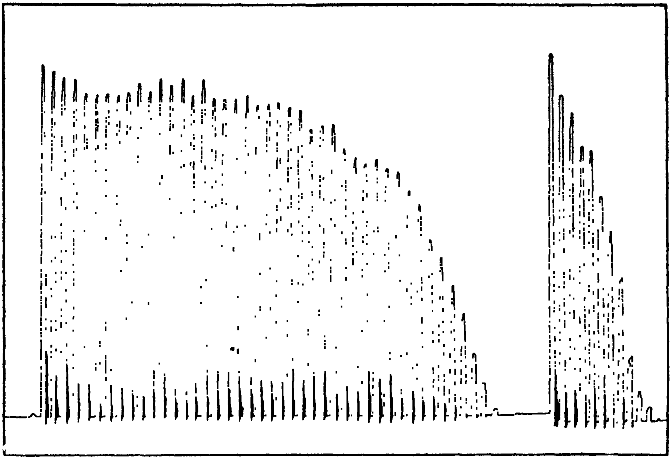
WHEN DR MAGGIORA USED THE ERGOGRAPH

These fatigue tests were carried on at different times for about seven years; and from first to last each man always made the same curve for the same condition of body and mind.

There were fluctuations in health, and the curve changed to correspond. There were fluctuations in excitement, in brain fatigue, in rested conditions, and the ergograph gave a correct report for every change. Indeed, it finally came to such a pass that even when the men made no confession about their recent doings, if either of them went to the ergograph, used it, and went

away, Dr. Mosso, by looking at the curve, could tell with remarkable truth the state of mind or body of the one who did the pulling.

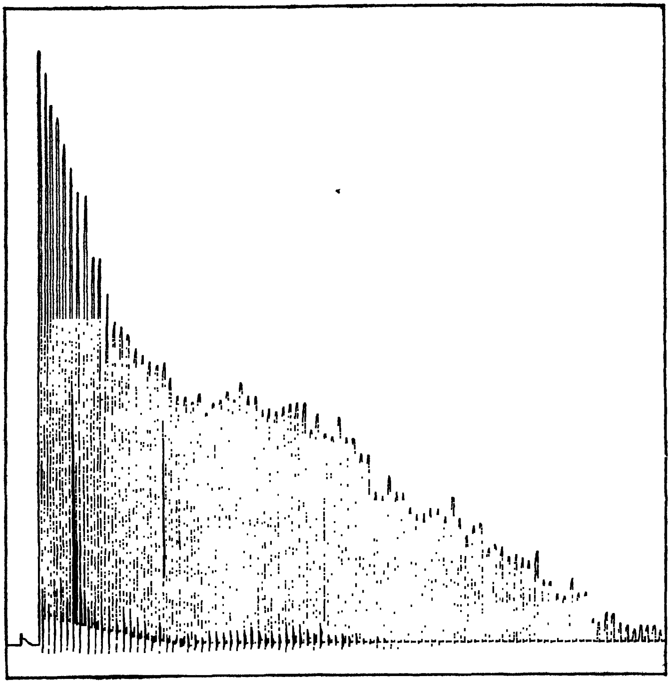
In proof of this, turn to Dr. Maggiora again. With all the other teachers in the University he was obliged



RECORDS MADE BY DR. MAGGIORA BEFORE AND AFTER AN EXAMINATION

to examine his students in June and in October of every year. He taught hygiene, and as he had many students, as he examined them orally, and as he was anxious to discover just how much each of them knew, he exerted himself with the greatest diligence over the questions he asked. In a way it was as if he were testing the brain of each student by his own brain. This is always hard work, and by the end of the examination he was probably quite as tired as his students.

He had given the ergograph one record before the examinations began; as soon as they were over he gave it another; and the time which they required was from two o'clock in the afternoon until after five. This meant



Record made by Dr Maggiora after Three Days of Rest

three hours and a half of hard, steady brain work, with idle hands in the meantime. Now study the record and know by the long pull and the short pull that there is close connection between brain fatigue and muscle fatigue.

We see that a man may exercise his brain so intensely as to reduce the power of nervous control elsewhere, and that in such a case nerves cannot compel muscles to do their usual amount of work. The following, then, is the first great lesson of fatigue.

Hard brain work lessens the muscular power of the body.

Later came a test which proved another point.

Again it was examination time for Dr. Maggiora, and we have a tracing which shows how the muscles felt when the last examination was over. Dr. Mosso now wished to know how promptly the brain could recover itself and improve the record. Accordingly, Dr. Maggiora went out of town for three days of idleness. During these days he did no brain work whatever, and when he came back to Turin not a word was necessary about his feelings. The tracing of the ergograph told the story.

The startling contrast in the two records shows that even a brief rest may do wonders for the nerves and the muscles of a man whose brain is tired.

Another valuable fact about Dr. Maggiora's record is that in June and July, 1890, other tracings were made showing wonderful improvement. He now raised a heavier weight with his finger and raised it much oftener than before. The explanation turned out to be the state of his general health. He was heavier, stouter, and stronger. "Never before quite so well," as he told

Dr. Mosso. Moreover, he had been resting and not teaching. Even in this condition, however, there was the same astonishing contrast between the tracings which his finger was able to make before and after carrying on a long oral examination.

These facts which Dr. Mosso gave to the world were astonishing to all brain workers. They teach lessons of great importance.

1. Muscular work done by one who has an over-tired brain is poor in quality.

2. The surest and quickest way to rest an over-tired brain and to make muscles do good work again is to give both brain and muscles nothing to do for a season.

In view of these facts, if my friend is anxious to win a college boat race, shall I encourage his plan to take a hard examination just before he starts on the race? By no means, for, as proved by the ergograph, his muscles will not do their best work for him if he starts with a tired brain.

If children feel tired out after a hard examination in arithmetic or hygiene, shall we urge them to go out of doors and take vigorous exercise? Get them out of doors, by all means, but encourage them to postpone violent action for a season. Rather let them stay quietly in the sunshine and in the open air; let them occupy themselves with simple games and quiet sports.

Work the muscles vigorously when the brain is not too tired, but when it is exhausted deal kindly with your whole body; relax your muscles, let your thoughts wander at such times, let nature help you. Use your sense and good judgment always. Energetic exercise of the brain, hard thinking, is most wholesome. Without it you will never gain mental power; but constant overwork, a constant feeling of being tired, is quite another matter. It is nature's way of calling for rest, and nature is a stern ruler. It is not safe to persist in breaking the laws of the nervous system.

CHAPTER V

TIRED MUSCLE AFFECTING BRAIN POWER

It was quite as important for Dr. Mosso to know how the brain acts when muscles feel tired as to know how muscles act when the brain is tired, and for this purpose he studied swift-flying birds.

He went to Palo, near Rome, in Italy, and waited for the quails to arrive from Africa. The distance they fly in crossing the Mediterranean Sea is three hundred and forty-one miles. Their rate of flight is about thirty-eight miles an hour, and they make the trip within something like nine hours. Surely no muscles could work harder than the wing muscles of these small voyagers, and such work as this must bring great weariness. But how does the weariness show itself? How do birds act when they are tired?

Dr. Mosso says that he found some of these birds so tired that when landing time came they seemed to pay no attention to the high obstructions in their pathway. They had crossed the wide stretch of water, they had reached their destination; but now, instead of dropping safely to the ground or alighting on some tree top or

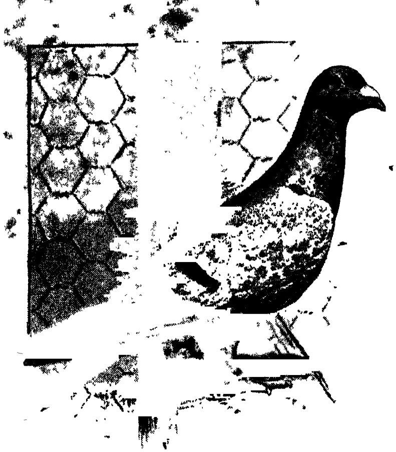
roof, many of them in their swift flight dashed their heads against trees and houses and were killed at once. It looked very much as if they were so tired that they could not recognize things and had with dazed vision flown against the obstacles without seeing them. No wonder the birds were killed, for they were moving as fast as many a local railroad train ever travels.

But we wonder why tired muscles should interfere with eyesight. Carrier pigeons help answer the question, and Dr. Mosso pressed them into service for the special purpose of making discoveries.

He began his work in 1885 with fifty young pigeons. Each pair was located in a small dovecote of its own fastened to the wall, and each dovecote was numbered as carefully as your home is or mine, for no pigeon ever cares to leave its own pleasant habitation. It was, therefore, just as well to number each home as to call each bird by a name which belonged to no other.

Since these fifty pigeons were all young, each had to be trained, for only after training is a carrier pigeon able to find its way across land and sea to its home. Fortunately it is not a difficult matter to train these birds, yet before the training begins there are three important requirements: the dovecote must be pleasant in itself and pleasantly located; the surroundings must be peaceful and quiet; the pigeons themselves must have such food as pleases them best.

The one important object is to make each dovecote so attractive to its pigeon owner that, even from a foreign city or a distant land, they will be homesick to be back again. In other words, the love which pigeons have for their home must help do the work for the man who trains them.



A HOME-LOVING CARRIER PIGEON

Dr. Mosso's first step was to force his contented young pigeons from their homes for short trips. On the first ventures they were timid, they seemed distrustful, they stretched their necks and peered around. A few of them, however, being braver, would fly to a neighboring roof and glance about the region; but none stayed out long and all were soon back again, cooing in their dovecotes.

At a second venture, on another day, a few would fly rather high, and move in large circles round and round. Evidently they were studying the landscape and getting the relation of things, for they always ended with a straight, true flight to their homes. It was evident that with each outing of this sort they were gaining a wider view of things.

In the course of time Dr. Mosso dared to take a basket of his pigeons to a place half a mile from home. There he freed them. They rose high in the air, made a few great circles, then flew as before, straight and swift, each to his own habitation.

As weeks passed, the distance from home was increased, until at last these well-trained birds could find their way back from a place three hundred miles away. Older pigeons and younger pigeons were often carried in the same basket to some distant point and there released. All would rise together and take the wide view of river and valley and mountain round about, but it was always the older pigeons that made up their minds most promptly, showed the least hesitation about the direction they were to take, reached home soonest, and were the least tired. The younger birds often arrived hours afterwards and seemed much more exhausted.

It was from these younger ones, then, that Dr. Mosso learned his best lessons for science. A friend would take a carefully selected basket of birds to Bologna or to some other distant city, and at the moment when he opened the basket and let them fly upward, a telegraphic message carried the tidings to Dr. Mosso.

He was thus quite ready to expect the birds, and as the time of their arrival drew near he would take his telescope, go to the top of a neighboring church tower, and watch for their coming. But sometimes they came like

such a flash, like such a stretch of swift-moving beaks, feathers, and feet, that they stood on the roof of the dovecote even before he was sure he had seen them.

The journey from Bologna to Turin is three hundred miles, and, as I have said, every bird is tired after such a flight as that, but the youngest birds showed it most. Sometimes they sat crouched and motionless on the roof for several hours before they began to fly about again, or before they had even energy enough to pop into their dovecote.

Dr. Mosso knew that it was through just such cases as this that he could best make his discoveries and best teach human beings what they need to know. He therefore carefully examined various birds in different ways, giving them no pain whatever from the examination, and he saw that the color of their wing muscles was much darker than that of the pigeons who had not been flying. This proved that an extra supply of blood was crowded into all the small blood vessels of the hard-worked muscles. As we learned, even so long ago as in *Good Health*, vigorous exercise always sends blood to the exercised region. So it was now with the pigeons.

Next followed the brain examination. It appears that sometimes carrier pigeons are not able to meet the test of their own flying. They reach their destination too exhausted to recover their strength at once. It even

happens that sometimes they die as the result of their great exertion. And what does the brain of an exhausted bird show? Is there any explanation of the apparent failure of the eyesight of the flying quails from Africa? Yes, the explanation was as evident as possible. Every person who studied the case with Dr. Mosso appreciated the situation at a glance, for the brains of these pigeons were as pale as if no blood belonged there. Not so, however, the brain of such pigeons as had stayed at home; for them there was rich red blood, and brains as full of it as yours or mine.

The case was proved. Birds that are exhausted by muscle work have pale brains. Clearly, then, the wing muscles of those African quails had robbed the brain of blood. There had not been enough of it to keep the nerves of sight in active condition. Exhausted birds had, therefore, failed to see the houses and the trees against which they flew.

When he was a boy my gardener once had an experience quite like that of the quails. It was in connection with a ten-mile bicycle race. For the sake of keeping an eye on his own progress he fastened his watch to the handle-bars, and at the given signal off he started on his course, to win if possible. For a short time he followed the watch hands as he moved onward, harder and faster. Ere long, however, although he still saw the face of the watch, he could not decide what time it

was. Evidently his brain was not getting blood enough to do its work properly.

He won the race; but long before the end he had given up trying to come to any conclusion about the time.

The lesson from carrier pigeon and bicycle race is that he who wishes to do profitable work with his brain must not expect much of himself while he is doing violent muscular work or immediately after it. No man can do much with a brain that has been robbed of its blood supply.

After a hard day on the athletic field or on the farm tossing hay, suppose a tired boy exclaims, "I 'm dead tired!" Shall we advise him never to get so tired again? Certainly not. There are times when physical fatigue is the best thing in the world for any of us. But if that tired boy also says, "I suppose I 've got to study my geometry no matter how tired I am," we shall know enough to tell him that it is cruel to his brain to try to make it work when his muscles have robbed it of its nourishment, and that what he learns at such a time is quickly forgotten. We shall advise him to rest for a while, then begin his brain work, knowing that when rested he will probably accomplish twice as much in half the time.

Once again, then, about the boat race. It would be even more foolish to expect to pass an examination

immediately after a hard race than to expect to win the race immediately after a hard examination. The second great lesson of fatigue is:

Hard muscular work reduces the power of the brain for a season.

Ambitious people often defeat their own plans by being ignorant of these facts about muscle and brain fatigue. They keep themselves under constant pressure — sit up late at night, sleep too little, waken too early in the morning, and get up tired.

It is this sort of overwork, this being too tired, that is dangerous. It results in what we call cumulative fatigue; for the weariness of one day is passed on to the next day, and the outcome of this kind of fatigue stunts growth of body and hinders vigor of mind.

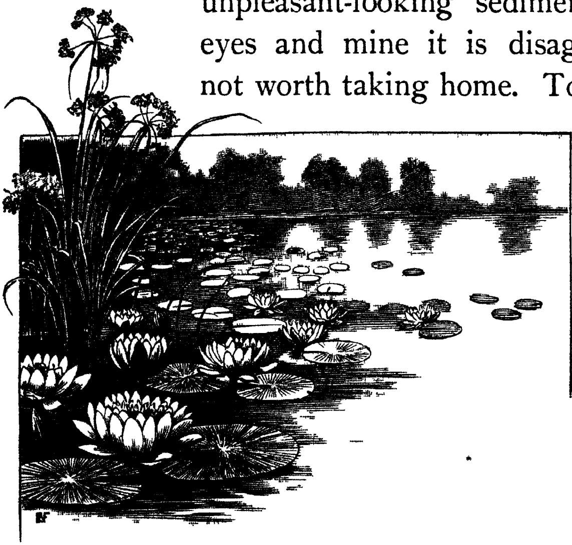
We are at liberty to be as tired as we please when we go to bed at night provided we are rested when morning comes.

A true scientist not only studies the nervous system as he finds it in human beings to-day but he traces its history from the beginning until now. We, too, are scientists. We, too, intend to do scientific work in this book. The next chapter will, therefore, give us a glimpse at the starting point of that which controls every thought, every act, and every feeling of our lives.

CHAPTER VI

WHERE THE NERVOUS SYSTEM STARTS

From the bottom of some stagnant pool you and I and the scientist might each carry away a cupful of unpleasant-looking sediment. To your eyes and mine it is disagreeable stuff, not worth taking home. To the scientist it is a liquid storehouse of treasures for his microscope.



A LIQUID STOREHOUSE OF TREASURES

But he must hunt for these treasures carefully. He puts a drop of the liquid under the object glass of his microscope. His eye studies it from above, and he sees tiny scraps of things of every form and shape. Part is lifeless matter that

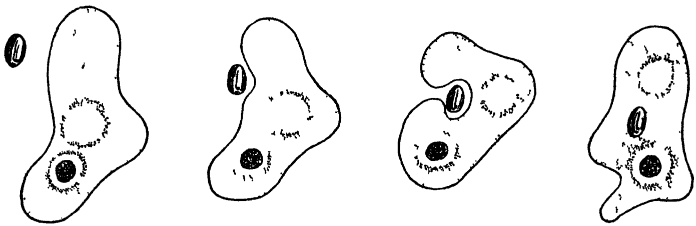
never moves — bits of leaves and grass and insect wings that sank to the bottom from the surface of the pool and are decaying now in the water. These he does not care to keep. He also sees active, darting creatures that are as alive as possible. Many of them are microbes of various sorts. They are full of interest to him, but just now he is hunting for something else.

At last he finds it, the amœba — a slow, smooth, glassy-looking object, with an irregular shape. You or I looking at it might mistake this particular amœba for some lifeless thing. Not so the scientist; he knows the difference. He tells us to look through his microscope and keep an eye fixed on that amœba until we see something worth reporting; then it is that we make our first discovery.

We notice that even while we are watching it the small object with its crooked outline is changing from one shape into another, and it seems remarkable that each shape should be different from the one it had before. The change is in the projections that are poked out from one side or the other like impromptu arms and legs.

After sending out each projection the amœba shifts its position slightly, and it is easy to see that if the shifting creature had a bony body it could not keep up such movements endlessly. In point of fact, it has no bones whatever. Instead, the entire bit of substance is

as soft as jelly and almost as transparent. It is called protoplasm — a word to remember, for protoplasm is an important part of everything that lives upon the earth. Each arm or leg of this bit of living substance which we call amœba reaches out for no reason that we can discover. Sometimes there may be three projections, at other times a dozen, from the same amœba. One is sent out after the other, but there are no sudden jerks connected with the moving, as is the case when a



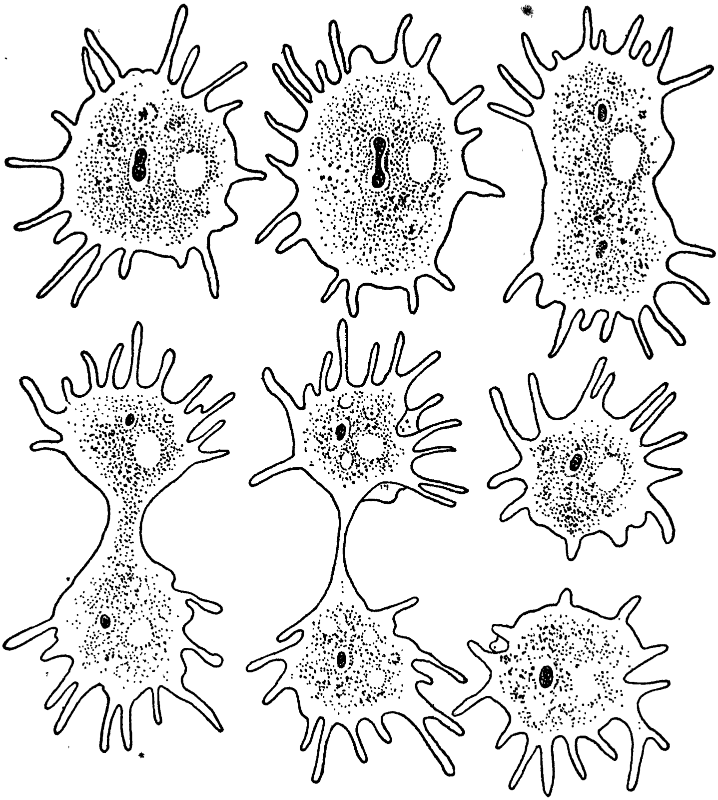
AN AMŒBA GETTING ITS FOOD AND SWALLOWING IT

man strikes out with arms or legs. Instead, each movement is graceful and gentle. At the same time we notice that little by little the amœba has moved across the glass, and that on the way it even helps itself to food.

Watch the longest arm and you will see that the rest of the amœba gradually flows into it until what was its arm is now its body. Soon a new arm stretches from the body, and into this again all the protoplasm flows, so that at every step there is gain.

That is the way the amœba creeps. More than this, in the progress you notice how it gathers food. As it

stretches itself out, an arm touches some sort of amœba food — a microbe plant it may be, a microbe animal, or,



THE AMŒBA AS IT MULTIPLIES

perchance, a tiny scrap of something else. Whatever it is, the eating process never varies, for the arm simply settles itself close to the desired food, presses up against

it, surrounds it, and gradually that morsel has passed inside the amœba. There by degrees it grows smaller, fading from sight, and we know that the amœba has captured its prey, has swallowed and digested it, and is ready for more. If any part of the food is indigestible, it will be seen to pass out of the body later.

Naturally enough, the more an amœba eats the larger it grows to be; and then, after a while, comes the dividing and the multiplying. If you should have the good fortune to see this done, the chance is that you would carry on a series of exclamations which would correspond with each step of the dividing process.

First of all, however, notice the spot in the body of the amœba. Such a vital point exists in every amœba that lives to-day. It is the nucleus — the very center of life, as we shall learn later. Here, now, are the exclamations which a person is apt to make as he looks through a microscope and for the first time sees an amœba divide.

"What a queer little creature!"

"Why, it's stretching itself out!"

"It's turning into a dumb-bell!"

"It's actually pulling itself in two!"

"Yes, it has done it! There are two of them now — twins, but they act as if they didn't know each other by sight!" The slow-moving, tireless activity of this living creature is indeed an ever-fascinating study for those who watch him through the microscope.

The amœba has but three rules to live by:

1. Adding food to itself.
2. Dividing the protoplasm, nucleus and all.
3. Multiplying itself by two.

After the dividing, each newly made amœba owns its fraction of the nucleus and is a separate, living creature. It falls to creeping and eating and growing as its parent did. It is, indeed, as we have seen, a part of its parent. Soon it has reached full size. Then it, too, divides and multiplies. Thus does amœba life and history go on through the ages.

As for any sign of a nervous system in the body of the small animal, what does the scientist find? Just one important fact. When the end of an outstretched arm of protoplasm is touched it swells a trifle, and the impulse, as it is called, seems to move as a sort of wave across the body of the amœba. Not a thread of nerve is to be found in the bit of protoplasm; no sign of brain anywhere; no spinal cord; nothing definite to carry any sort of stimulus in a straight line from one point to another. In place of all this there is the slowly moving wave which affects the whole of the amœba as far as the wave travels.

We see, then, that just as any part of this surprising protoplasm may, at a moment's notice, become arm or leg, body or stomach, so any part may also be the nervous system itself, carrying messages across from side to

side. This is the special reason why a book on control must start with protoplasm in the shape of an amœba, for many scientists spend their lives in tracing the road that leads from sensation in an amœba to sensation in man. At each end of the road is a living machine — amœba at one end, man at the other. One is a single cell of protoplasm which, through all its eating, creeping, dividing, and multiplying, never increases the number of its cells. The other is made up of cells by the countless million.

Side by side with the amœba in the world of living animals is his legion of single-celled relatives. Some are larger, some are smaller, but not a creature of this host has either head or tail, either bones, muscle, sight, hearing, or smell. Nevertheless, like the amœba, they all live, grow, divide, and prolong their days beyond the reach of our imagination. On the other hand, in contrast to this fascinating group of single-celled animals, stands every other living thing from microbe to man and elephant that is composed of more than one cell. Of every size and shape, scattered wherever they may be, in water, earth, or air; whether they are worms, birds, beasts, or men — any living creature that has more than one cell belongs to the many-celled group.

We shall yet see how our knowledge of the amœba makes the structure of the nervous system of man easier to understand.

CHAPTER VII

OUR RELATIVE, — AMPHIOXUS

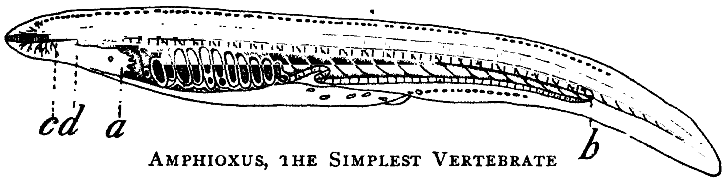
On the mantelpiece of the room in which I sit there is a small Japanese bronze box. It is an inch and a quarter long, almost square, and decorated on the outside with queer Japanese figures. Inside, in a vial an inch long, very slender and filled with alcohol, is a curved white object, with what seems to be a dark shadow running along through its center from one end to the other.

This object has neither head nor tail, neither wings nor bones of any sort; but four years ago it was a living, darting thing that found food for itself in the sand on the seashore of Formosa. It buried its body in the sand and appeared to be nothing but a water tube, for a small, round opening at one end was surrounded by a waving fringe of fibers. This opening served for mouth, and into it the water went. On the under side of the body was another opening out of which the water flowed. The animal lived on the food which it caught from the water that passed through its body.

With all that it lacks then, this small creature is entirely different from the amœba, for it has at least a

mouth and a stomach. It has indeed much more than this, for the shadow which we see stretching from end to end is the simplest and the earliest style of backbone that scientists have ever found in an animal of any sort.

And because of this backbone the amphioxus is a relative of every other creature that has a backbone — human beings included. Scientists, therefore, study it carefully with their microscopes, and they discover what they call the nerve tube. This stretches through the



AMPHIOXUS, THE SIMPLEST VERTEBRATE

a, where water goes in; *b*, where water escapes; *c*, nerve tube, *d*, backbone

little fish close above the backbone. In fact, there is a groove on the upper side of the backbone just deep enough to serve for a nerve canal in which the nerve tube rests. Slender nerves stretch from this tube to different parts of the body.

Even as they study the backbone and the nerves of the amphioxus, so also do scientific students follow the history of the animal from the time it begins its life as an egg until it is full grown — two inches long and laying eggs on its own account.

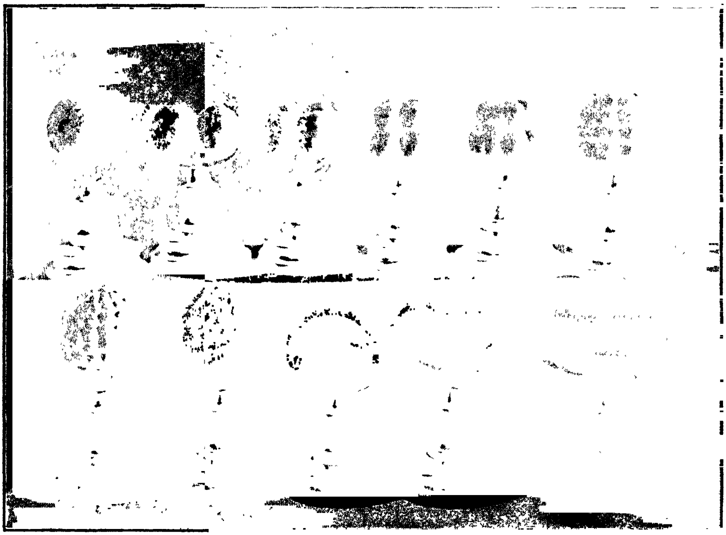
Amphioxus is its name — too long a name for so short a thing, but learned men do the naming, and

neither you nor I nor the amphioxus can help ourselves. These men have, at the same time, taught us how to think hard, and how to jump so far in our thinking that we are able to see some connection between amœba and amphioxus. We may, indeed, trace this connection through the tiny, freshly laid egg of the amphioxus, for it seems that this egg is as truly a single cell as is the amœba itself. Moreover, the egg is quite like the amœba in the way that its one cell becomes many cells. In point of fact, the dividing and multiplying of the cell of the amphioxus continues in true amœba fashion, although now it is all done within the egg itself.

Follow the history of a single amphioxus egg and see what happens. There is, as I have said, but one cell to begin with. As soon as this has been fertilized, as it is called, by coming in contact with another cell from another amphioxus, the dividing begins. That first cell now becomes two, the two become four, the four become eight. Then there are sixteen, thirty-two, sixty-four, the number doubling each time, because each new cell is constantly multiplying itself by two. Each has its own nucleus and each is as complete as an amœba, with the remarkable difference that not one of the number makes the slightest effort to get away from its fellow. As they divide and multiply, they hold together from the very first, and the scientist who knows what is happening simply says that the young amphioxus is

growing well in the egg; that it will soon be perfectly formed.

When the cells have divided and subdivided long enough, the work of making the young amphioxus is finished. It now comes out of the egg, buries its body



ELEVEN STEPS IN THE EARLY GROWTH OF AMPHIOXUS IN THE EGG

From a photograph of a set of models showing each cell enormously magnified The three last models are of cross sections and indicate how the layers are being formed

in the sand, and begins to live the life which its ancestors lived. Before long it will send off a bunch of egg cells from its own body; and, if all goes well, if those eggs are not eaten by hungry fish or destroyed in some other way, the cell of each will go through the process of

multiplying and dividing on its own account until each egg turns out its own amphioxus.

The one great difference, then, between the amœba and the amphioxus, or between all single-celled and many-celled animals, is that in one case each separate cell leads an independent life, while in the other case the cells always cling together and each keeps its own place as a part of the living machine.

While the creature is being formed in this way within the egg, the work of each separate set of cells is definitely decided. See how it is with the amphioxus. The earliest divisions of the first cell are soon arranged in a hollow oval, one layer deep. Next, the oval has two layers, one outside, the other inside—just as would happen if you should take a hollow rubber ball and press one side of it inward until it touched the other side. From that point onward the growth of the animal is even more marvelous. For, little by little, out of those two layers, and out of a third layer which forms in the space between them, the amphioxus itself grows into shape.

No cell of the inside layer ever crosses the line and intrudes on the business of the cells of the other layers. On the contrary, each set continues busily at work multiplying and dividing within its own boundaries, doing its part in building the wonderful swimming machine called amphioxus.

When the building is done, when each cell is in place and each layer complete, then the scientist finds that the separate layers have developed into distinctly separate parts of the body, as follows:

1. The outside layer of cells has become the skin and the nervous system. It is to the study of this layer that this book is devoted.

2. The middle layer has become bones, muscles, blood vessels, and the egg-making part of the machine.

3. The inside layer has become the stomach and all the part which belongs to the digestive apparatus.

The special interest about these various facts is that the history of the egg of the amphioxus is precisely the history of the beginning of every other many-celled creature. Each starts with one cell and multiplies by dividing, until the animal itself is made on the pattern of the owner of the first cell. The egg cell of a hen ends by multiplying itself into the countless cells of a chick ready to hatch — claws, feathers, beak, eyes, and all. In the lizard's egg, so small and so round, the cells arrange themselves in the shape of a lizard, and when the work is done out pops a sprightly lizard, ready to live its happy life in the chinks and crannies of some stone wall. Cats and dogs and birds and you and I, all have the same history from the cell upward.

In some animals, as fishes, birds, and lizards, the cell leaves the body before the multiplying begins. It is

safely lodged in an egg that is stored with food for the growing life. In each case of this sort the cell multiplies within the egg after it is laid, until the entire animal is formed as we saw in amphioxus. The creature then comes out as a complete being — or, as we say, "it is hatched."

In other animals the cell stays within the body of its parent. There it grows and divides, even as it does in the egg outside of the body, until the animal is ready to begin life for itself. Then, "it is born," as we say. Kittens, puppies, babies, and multitudes of other animals are built up in this marvelous way; and, in every instance, the first cell decides what the completed creature shall be — whether fish, bird, beast, or man. That first cell also settles the question as to whether the creature shall have a backbone or not; and it is just here that our special interest in amphioxus comes in again.

The shadow which connects the pointed ends is the earliest form of backbone that scientists know anything about, and because of this backbone they call the little fish a vertebrate.

As it happens, the backbone of amphioxus is really no bone at all. The cells that build it up are simply stiffer than the other cells of the body, and they are packed close against each other, forming a backbone quite stout enough for any need.

But the nervous system of the amphioxus interests us more than any other part of its body, and the reason is very easily given. An amœba acts according to what touches it from the outside. In the amphioxus, however, gills, stomach, and muscles are each built up of separate sets of cells. They lie inside the body, and as nothing can possibly touch these cells from the outside, no part can ever tell for itself when to act or how to act. Naturally, therefore, to help them out in their emergency, there must be another set of cells as a center for feeling and commanding. These special cells must know what is going on at the mouth, in the gills, and on the skin. They must be able to direct the muscles to swim at any needed moment. They must lie close together so as to be able to influence each other and not send opposite commands here and there to the muscles.

Now in the amphioxus there are just such cells doing precisely this sort of work. Moreover, these nerve cells, as they are called, are all bunched together in the walls of the long nerve tube, and they have arms like those of the amœba, only longer, that reach to mouth and skin and muscle and gill. It is through these arms of the nerve cells that each part of the amphioxus knows what to do and when to do it.

Although each kind of cell in the amphioxus does its own work, nevertheless the whole structure of this headless fish is so very simple that I fear if any other fine

fish, with waving tail, perfect eyes, well-shaped head, and respectable backbone, took notice of such things, it might turn tail and swim away, disowning its poor relation.

We, however, turn tenderly to him because he helps us in trying to understand the growth of the backbone and the nervous system in all vertebrates — ourselves included.

CHAPTER VIII

CELL POISON

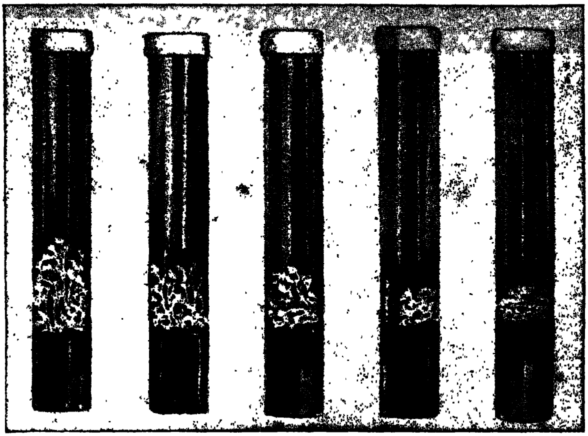
After scientists had learned that all living things are either single cells leading independent lives, or groups of cells working together in partnership, they began to ask questions about such other things as may help or hinder the work of the cells.

Alcohol thus came in for its share of attention, and the results were so surprising that newspapers and scientific journals hastened to print them for the world to read.

An experiment in this direction was made with a certain small jellyfish. Its home is in fresh water, and Dr. Richardson chose two from a tank in a botanical garden. Each was put into its own separate jar, and each jar was filled with tank water. In one the water remained as it came from the tank, and the fortunate jellyfish that was put into it moved about in lively fashion, making, on the average, seventy-five motions a minute.

The other jar of water had been specially prepared for the second jellyfish. Into it had been put one drop of alcohol for each thousand drops of water. This innocent-looking compound showed no trace of danger,

and when the little creature was put in, it acted as if it proposed to continue to move at its usual swift speed, but almost immediately its vigor oozed away, its strength failed, its movements grew slower and dragged. In fact



A B C D

. EACH TUBE WAS MOISTENED WITH THE SAME AMOUNT OF WATER BUT DIFFERENT AMOUNTS OF ALCOHOL

A, pure water, *B*, one drop of alcohol to 5000 drops of water, *C*, one drop of alcohol to 4000 drops of water, *D*, one drop of alcohol to 200 drops of water, *E*, one drop of alcohol to 100 drops of water

the jellyfish grew weaker so fast that within two minutes it not only ceased to move but sank to the bottom of the jar. It did not suffer, but was evidently paralyzed. At the end of five minutes it seemed so lifeless that Dr. Richardson put it into plain tank water again. Even then, however, the power to swim did not return.

This single jellyfish had taught the great lesson that alcohol, even when mixed with quantities of water, paralyzes groups of living cells.

It seems that other animals are even more sensitive. One drop of alcohol in four thousand drops of water soon kills any water flea that ventures to swim in the mixture.

Dr. Ridge has made experiments with the seeds of the cress plant. He took five glass tubes; put into each the same number of seeds, the same kind and quantity of earth, the same measure of water. This water, however, contained different amounts of alcohol.

Each tube was then sealed, and the picture shows what the difference of growth was in the different tubes.

There is but one explanation for the results. The seeds failed according to the measure of alcohol which they had received.

Ascending the scale of life, even chickens have had to testify about alcohol. Unfortunately for themselves, when the experiment was made they seemed to enjoy the drink. Time and again they hastened to use it; but if they were allowed to take it regularly, even in small quantities, they invariably died of exhaustion or paralysis within six or eight weeks.

They were not so wise as Bum and Tipsy, for, as we know, the dogs objected to alcohol. And yet, just because any poison affects dogs and human beings in

similar ways, scientists are laying much stress on Dr. Hodge's experiments on dogs. Indeed, Bum and Tipsy are now famous the world over. For full particulars turn back to *Good Health*. But the point to recall just now is that Bum and Tipsy received a little alcohol each day with their food, that the other dogs, Nig and Topsy,

BUM TIPSY NIG TOPSY

Photograph taken November 27, 1895

received none, and that in every test which was made Bum and Tipsy failed where Nig and Topsy succeeded.

In the gymnasium of Clark University, when all four dogs raced after the rubber ball, each did his best, but at the end of every test it was found that no matter how hard Bum and Tipsy worked, Nig and Topsy beat them every time. They brought the ball back twice as often.

Once more then, and even for dogs, alcohol is seen to poison and defeat the power of living cells.

Nevertheless, tests on human beings will always be more convincing than any other cell tests which can be made. With this in mind, in 1892 Professor Kraepelin, of Heidelberg University, Germany, did some experimenting in connection with the students of the place. He himself says that he really wished to save a little of the reputation of wine and beer, for he saw that science was crowding pretty hard against every drink containing alcohol.

In experimenting with his students Professor Kraepelin always gave small doses. He knew, as we do, that those who use alcohol frequently in large doses ruin their lives hopelessly. Proofs of this are on every side, in every land. There are, however, thousands of honest people who heartily believe that alcohol taken in small doses is a help to them on all sorts of occasions. It was in this direction, therefore, that Professor Kraepelin experimented.

Various university students were eager to know facts, willing to be tested, and quite ready to drink or not to drink, according as the progress of the investigation required. One test had to do with a man's quickness in adding up columns of figures for half an hour a day, during six days. Those who were being tested without alcohol added their figures as rapidly and correctly as they could. Then the alcohol period began. And now,

for thirteen days, these same students used the alcohol and continued to spend the half hour a day at their addition tables.

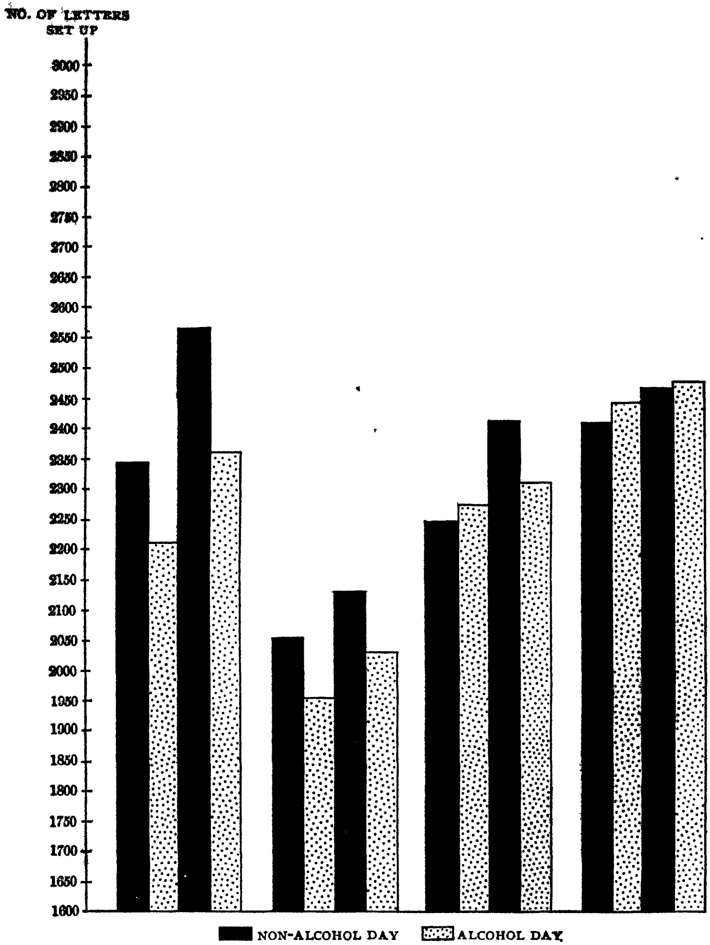
The work went more and more slowly during this alcohol period until the nineteenth day. Alcohol was then dropped. The men continued to add, and there was immediate and marked improvement in the work they did. This continued until the twenty-sixth day, when they returned to alcohol; and once again there was change for the worse.

Thus the seesaw between alcohol and no alcohol went on, until no doubt remained. It was clear to all that the men always did poorer work during the alcohol period and better work when they had no alcohol.

There was also the test with the typesetters in Heidelberg. Dr. Aschaffenburg carried on this set of experiments.

Four skilled men were chosen. Three were in the habit of using alcohol in small amounts, the fourth acknowledged that he took too much once in a while, but all were ready to go without it now or to take it, as the tests demanded. All four men were indeed anxious to know whether they themselves could use their fingers more swiftly and accurately with or without the alcohol.

The amount which Dr. Aschaffenburg gave them on the days when they took alcohol was one ounce and a



THE RECORDS OF FOUR MEN

Each group of four columns shows the work of the same man for four successive days. Each column shows how much the men were able to do on each of the separate days. Black columns show how many letters they actually set up on non-alcohol days. Dotted columns show how many letters they set up on alcohol days.

quarter; that is, the wine which they drank had about two and a half tablespoonfuls of alcohol in it.

The men drank it fifteen minutes before they began their typesetting. For fifteen minutes each day they worked hard and fast. Each did what he could to set up as much type as possible; and yet, as shown in the illustration on page 60, in every trial but one alcohol hindered and did not help them.

But — and here we meet a curious fact — in every case the men themselves thought they were doing better and swifter work when they used alcohol than when they did not use it. It appears, also, that this is the usual belief of those who use alcohol. In spite of this, however, many careful experiments which have been made prove that the opposite is true.

Sweden has turned special attention to her soldiers. She wishes to know whether a glass of wine or beer taken before the shooting begins will strengthen or weaken a soldier who tries to hit the enemy.

Lieutenant Rengt Boy carried on the experiments. The soldiers selected were picked men — all fine marksmen. Their targets were two hundred yards away, and guns and rifles were used. On different days the men, in groups of six, were tested with alcohol and without it. The amount of alcohol given was about three tablespoonfuls. Sometimes this was taken in the shape of wine or beer the night before, sometimes within an

hour of the target practice; and the result of it all was the discovery that, in every instance, each man in each group did his quickest firing and his best hitting when he had had no alcohol whatever for two or three days

TARGET PRACTICE FOR SWEDISH SOLDIERS
They need steady nerves

beforehand, and that he did his poorest work when he had used alcohol at any time within twenty-four hours.

As staff surgeon Mernetsch reports, "When under alcohol the result was thirty per cent less hits in quick fire, and the men always thought they were shooting faster, whilst actually they shot much more slowly. When slow aiming was allowed the difference even went to fifty per cent."

The same sort of testimony comes from Sir Frederick Treves of England. He says that "out of thirty thousand men who marched to the relief of Ladysmith, those who first fell out were not the fat or the lean, the short or the tall, the young or the old, but those who drank liquor." He says the drinkers on the march could not have been more plainly marked if they had had placards on their backs.

No doubt Emperor William of Germany has heard all this about the effect of alcohol on the living cell, for I am told that he allows no one to drive his automobiles who uses alcohol at any time. Clearly enough he wishes no hand on his machine that is less steady than it might be, no eye that is duller than it should be, and no wits that are less nimble than they need to be when emergencies arise.

The teaching of this chapter is that when such cells of the body as we have been studying about are reached by alcohol they are weakened and defeated, whereas when they are unreached by alcohol they are able to do their best work.

CHAPTER IX

STRUCTURE OF THE NERVE MACHINE

If by any clever process we could separate the nerves of a man from the rest of his body, if we could turn each one of these nerves into something stiff and firm, and then could stand the entire group on a pedestal in precisely the shape which it had when it did its work in the body, this network of stiff nerves would be so delicate and so closely woven together that we should be able to follow perfectly the outline of the man to whom it belonged. We should know his height, the breadth of his shoulders, the size of head, hands, and feet; while, at the same time, we should note that on certain parts of his skin the network was finer and more intricate than on other parts.

If, going further, we should cut that nerve figure open, we should find other great clusters of nerves that showed the outline of every separate organ of the body.

Having seen all this, unless we know the facts of the case, we might give a thousand wild guesses as to what this wilderness of nerves was for and how it was ever able to control the sensations and the movements of a human being.

Before the microscope was invented even the wisest men were obliged to do much of their scientific work by guessing. They first imagined that each nerve was a tube filled with something exceedingly fine and delicate, called animal spirits. The stuff, they said, was neither gas nor air, but something far more subtle than either. They thought that by means of this substance every nervous system did its feeling, moving, and thinking.

Later, other men supposed that the contents of the nerve tubes was something heavier than gas, and they called it nerve juice.

NERVES THAT SHOW THE OUTLINE OF THE HUMAN BODY

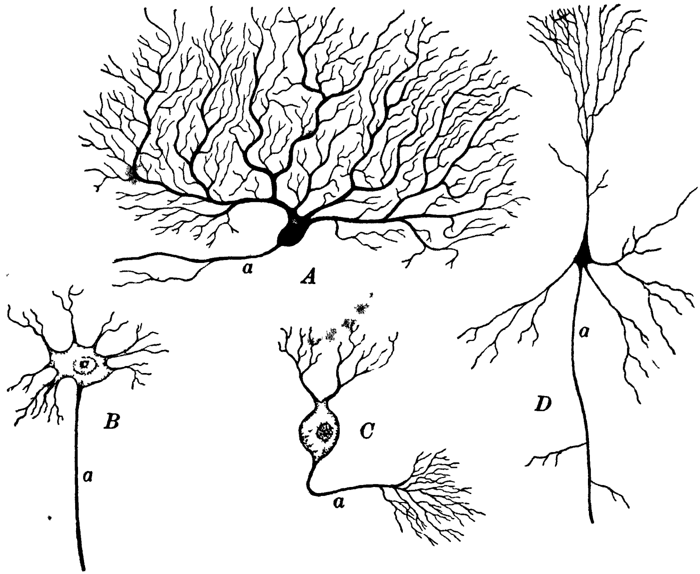
In recent times, however, the microscope has done as much for nerves as for microbes and the amœba. It has destroyed numberless old-fashioned theories, and has shown that the entire nervous system is simply a construction of nerve cells and their longer and shorter arms.

We ourselves are able to believe this at once; for our acquaintance with amœba and amphioxus has shown us that each separate part of a living creature is a closely connected mass of cells, and that each part carries on its own particular line of business. In addition, however, nerve cells are seen to have special peculiarities of their own. The microscope shows that each one of these has armlike projections which resemble the arms of the amœba, that they are sometimes very long, and that it is the countless millions of slender arms from countless millions of nerve cells that give us our nerves.

Scientists tell us that every white nerve is a bundle of nerve fibers, each one of which is neatly and snugly wrapped by a fatty covering that makes it look white; and that the difference between large nerves and small nerves is quite the same as the difference between large bundles of telephone wires and small bundles of wires, for in each the number of separate strands explains the size.

Since we know so much about the amœba, we are ready to understand at once that each separate fiber in the bundles is the long arm of some cell at a distance from it, and that the arm of the nerve cell is as truly a part of the cell itself as the arm of an amœba is part of the amœba. Moreover — and this is quite an important point — the substance of the nerve cell, arm and all, is similar to that of the amœba. Both are protoplasm.

Yet again, even as the amœba has several arms, so, too, have most nerve cells. In the case of the nerve cell, however, one arm is apt to be entirely different in appearance from all the others. It stretches off to a greater



FOUR NEURONS

A and *C*, from the cerebellum, *B*, from the spinal cord, *D*, from the cerebrum; *a*, the axon. The cells *A* and *D* are stained so that the main body and the dendrites are black; *B* and *C* show the nucleus

distance and has branches that extend from it at right angles. This long arm has its own name. It is called an axon. A nerve cell never has more than one axon. All the nerves that we see stretching everywhere on the surface of the body and within it are nothing more nor

less than larger or smaller bundles of these axons, and each axon belongs to its own particular cell somewhere at the center of things.

When a nerve cell has several arms it is always easy to pick out the axon, because the other arms are shorter; they also branch in forked and crooked fashion like the twigs of a tree. Indeed, they are called dendrites, because "dendron" is the Greek word for tree.

Since the nerve cell as a whole is a complete individual, it is natural that it should have its own distinct name. Scientists call it neuron, and we shall adopt the same name, for that one word covers the entire structure of cell body, axon, and dendrites. We might express it thus:

$$\text{neuron} = \begin{cases} \text{cell body} \\ \text{axon} \\ \text{dendrites} \end{cases}$$

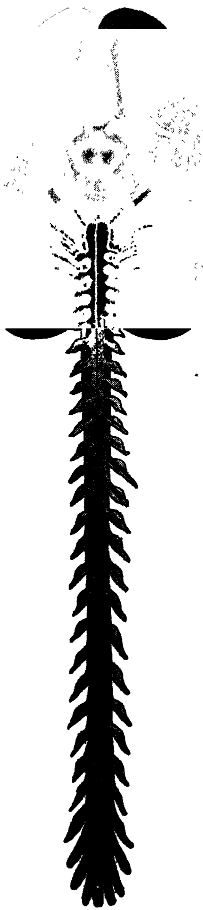
CHAPTER X

STRUCTURE OF NERVE MACHINE (CONTINUED)

The amœba with its nucleus moves from place to place; and, as we know, it keeps up an ever-changing life.

But the neuron, which also has a nucleus, never moves from its place. Axons do certainly stretch out from the cells while the child grows from two feet to six feet in height; dendrites may also increase in number on the different cells, but the cell body of each neuron is forever stationary. It is not entirely separated, however, from other cells of its kind. On the contrary, the cell bodies of the neurons are clustered together in bunches. Multitudes of them are in the brain, protected by the skull; still other multitudes are in the spinal cord, protected by the backbone; and yet others are placed in groups that are unprotected by any special bony covering. Each of these latter bunches is called a ganglion.

Wherever nerve cells are clustered, whether in brain, spinal cord, or ganglion, there we have that interesting place, a nerve telegraph station. It resembles a city telegraph station in two ways:



SPINAL CORD AND UNDERSIDE OF BRAIN

The bone covering is removed and we see the beginnings of the spinal nerves

1. It has axons that do the work of wires, and stretch away from the central station to different points here and there. These carry messages hither and thither.

2. If an axon is separated from its own particular cell in that central cluster, it is as useless as is a telegraph wire after it has been separated from its telegraph station.

We see, then, that the vital part of each neuron is the gray cell body, and we realize why it is that a cluster of hundreds and thousands of these cells becomes one of the most fascinating centers of activity in the world. Especially so, as it appears that each axon wire that enters the central station is responsible for one sort of message alone, and that it can never carry a message of any

other sort. See how this is in the spinal cord, within the backbone. A list of statements will make the case plain.

1. Thirty-one bones called vertebræ are joined together to make up the human backbone.

2. By the way the bones are joined, one above the other, a round opening is left on both sides of each bone, making sixty-two holes in all.

3. Through each of these sixty-two holes goes a nerve about as large as a quill toothpick. It is called a spinal nerve, because it comes from the spinal cord.

4. Each of the sixty-two spinal nerves is made up of two roots which join each other before they come out of the backbone through the hole.

5. On one root of each spinal nerve there is always a spot that looks swollen. It is a ganglion, that is, a bunch of cell bodies.

6. The other root of each spinal nerve is smooth. It has no ganglion.

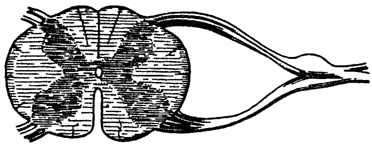
7. Every message of every kind that goes to the brain from the body travels upward through the swollen root; it goes by the road of the ganglion.

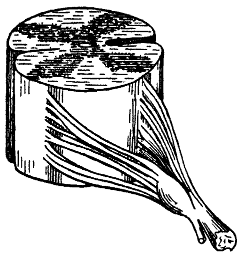
8. Every message of every kind that goes to any part of the body from the brain goes down through the smooth root.

To remember which messages use which root we might think of those that go to the brain as climbing

up, because they use the swollen root; and of those that come from the brain as slipping down, because they use the smooth root.

Since the two sets of fibers carrying messages in opposite directions are so close together, the ignorant person might wonder whether or not any mistakes are ever made in the work they do. The answer is, that this never happens. From birth to death every fiber that passes through the swollen root carries messages upward, while, at the same time, every fiber of the smooth root hurries messages downward. These countless messages, moving in opposite directions, cannot intermix, because each nerve fiber is separated from the others by its own particular outside wrapping.



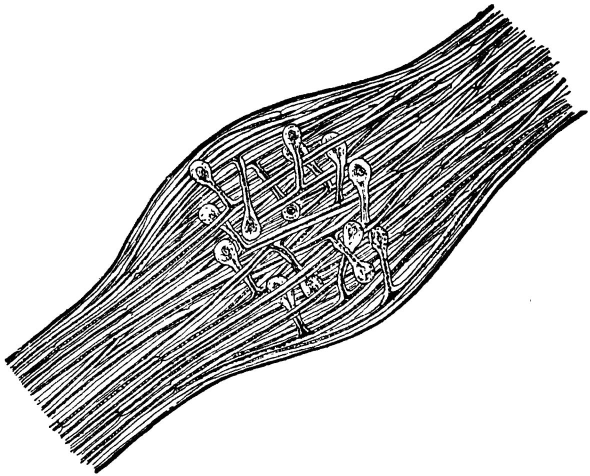


THE SMOOTH AND THE SWOLLEN ROOTS AS THEY JOIN THE CORD

The two roots join each other and are wrapped together as a single spinal nerve; and thus are the sixty-two spinal nerves formed. Each passes out through its own opening between the vertebræ, yet never in a single instance does any fiber in any bundle carry a message the wrong way or exchange its message for that which a neighbor fiber is carrying. Thus once again do nerve fibers remind us of telegraph wires.

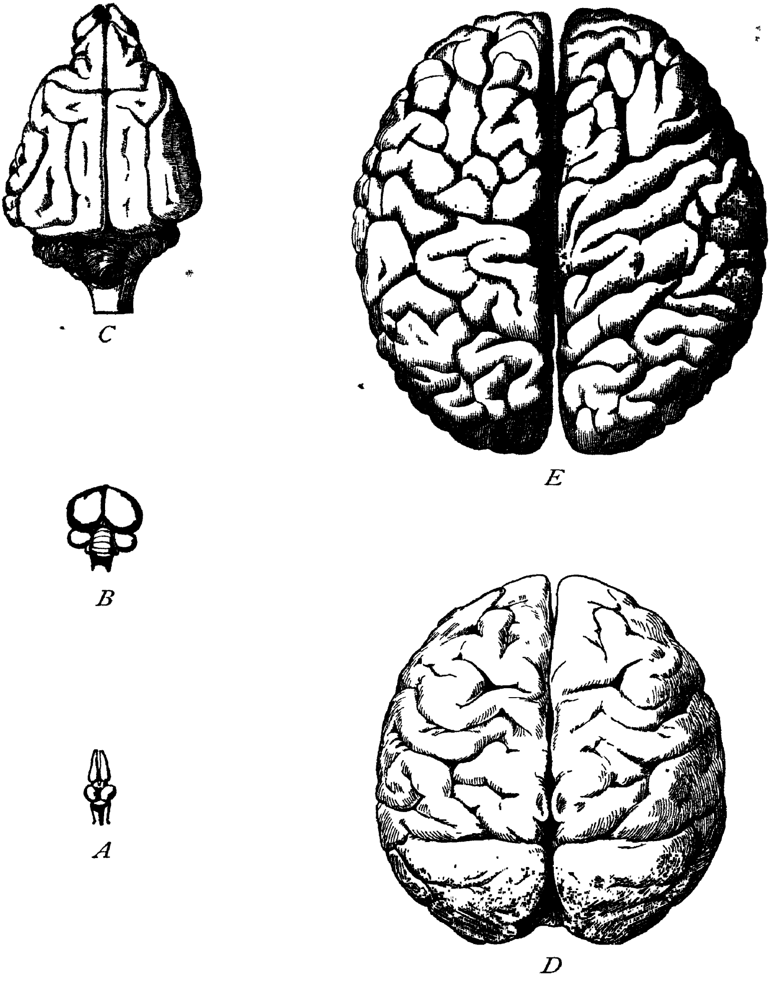
And now we are ready for the explanation of the gray and white substance of the brain. The gray layer is a mass of millions of cell bodies packed together and joined to each other by dendrites and axons.

The white stuff is a compact mass of axons, each one of which stretches away with its silvery sheath from its



Ganglion of a Spinal Root cut Open
Here we see cells and axons

individual cell in the gray layer. Millions of these axons join one part of the brain with another part of the same brain. Still other millions go downward towards the spinal cord, and there, within the firm protection of the backbone, impulses of every sort fly upward to the brain, while, at the same instant, on separate roads, countless commands go from the brain to the muscles of the body.



FROM SMALLER BRAIN TO LARGER

A, frog; *B*, pigeon; *C*, dog; *D*, chimpanzee; *E*, man. Each is three eighths its normal size. Notice the convolutions that increase as intelligence advances

As a rule, white color anywhere in the nervous system stands for nerve fibers, and gray color shows cell bodies; but the arrangement of the two colors is rather interesting. In the brain it is gray outside, white inside; in the spinal cord it is white outside, gray inside.

Close examination proves that it is from the white part of the cord that the sixty-two bundles of axons, called spinal nerves, stretch away from the backbone, and that the spinal cord is therefore the highway of travel between brain and body.

It is easy to talk about neuron, about cell body, axon, and dendrite, yet each separate one is so small that without a microscope no human eye will ever find a neuron anywhere in the nervous system. In fact, even to the keenest eye, if it is unaided, the contents of the skull and backbone will always look like nothing but a mass of marrow.

In shape, however, the brains of living creatures may be arranged as a ladder. At the foot stands amphioxus, with its backbone, pointed at both ends, its nerve tube, and its simple nerve branches. At the top stands man, with his masterful brain and his superb nervous system.

CHAPTER XI

NEURONS AT WORK

When a baby sees a flame, laughs with joy, thrusts his fingers into it, and pulls them out again with a scream, several sets of fibers have been at work.

1. One set, from the eyes, compelled the brain to see a lovely color.
2. Another set brought word from brain to hand muscles, " Feel of it."
3. A third set carried a stimulus to the brain, which seemed to say, " Something dreadful is happening to the fingers."
4. A fourth set brought the prompt command, " Pull the fingers out of the color as fast as possible."

In the meantime other sets of fibers set other muscles to work, so that at one point the baby opened its mouth to laugh with joy, and a moment later opened it again to scream with pain. Still other fibers commanded the heart to pump faster and send more blood to the excited head. They commanded the tear glands to manufacture salt water with lightning speed and in great abundance. They set lungs and vocal cords to

work, too. And as the result of so much stimulation sent up to the brain and so many commands sent down from the brain, we end with a nervously exhausted, screaming, red-faced, tear-stained baby — rather a dejected-looking living machine.

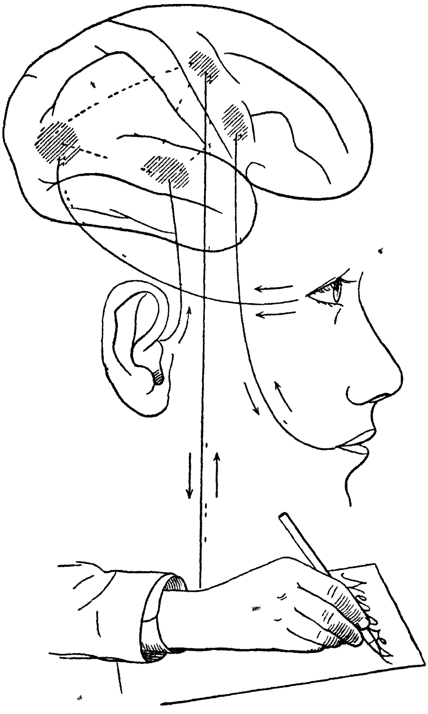
ONE SET OF FIBERS AT WORK

If we could ever follow any series of messages up and down, we should learn to understand the marvel of the relay race as neurons carry it on.

It seems that the tip end of each axon, as it enters the cord from its own cell — wherever that cell may be—is divided into even finer threads than itself; and that these threads are intertwined with the dendrites of what is known as a central neuron. It also appears that multitudes of these special central neurons carry on rapid business within the spinal cord and brain, although they themselves never send either axon or dendrite out of those regions. This,

ANOTHER SET OF FIBERS AT WORK

indeed, explains their name. They seem to be hard-working messenger boys, who do nothing more than to race their messages upward or downward or across the cord or brain, as the case may be.



ROADS TO AND FROM THE CORTEX
Sight, hearing, and touch have special centers, but taste and smell are near together

Each central neuron is supplied with its own cell, axon, and dendrites. They are of various sizes and shapes, but so long as they are in good health they never fail to deliver the messages intrusted to their keeping.

In doing their work it is as if they clasped tendril hands with each other, for they always receive the message through the fine fibers of one outstretched hand, and, like a flash of lightning, they pass it on through the fibers of another outstretched hand.

Messages from remote regions of the body enter the cord and quickly fly from hand to hand on their way

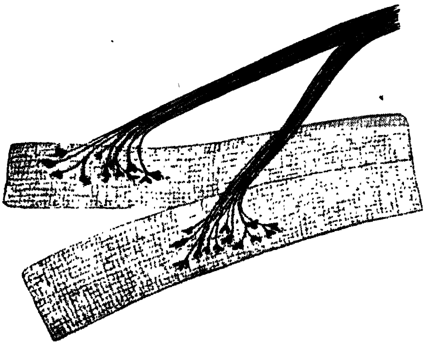
upward to the brain, and there, in what is really the great central station, the various kinds of messages are recognized and attended to. Commands are issued at once, and each of these commands now goes by its own road downward through the spinal cord into the smooth root. From there it is flashed across an unbroken, long-extended axon to a toe, or a finger tip, or to any muscle of the body that is to be controlled by it.

The longest axons are those which carry an impulse from the toe up into the backbone, and that bring commands back over the same distance. In a tall man these fibers, carrying messages in one direction or the other, may be four or five feet long.

From what looks like the confused medley of axons under the skin it would seem as if messages might sometimes get lost on their journey; as if those intended for one particular spot might find themselves delivered at the wrong place — bringing despair to the brain. But this never happens. The confusion is only apparent. It is caused by the way the bundles of fibers are variously bound together.

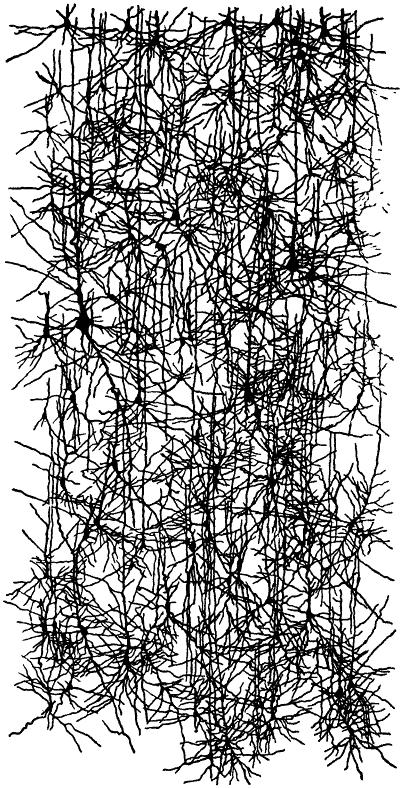
If we had eyes keen enough to see the fibers themselves, instruments delicate enough to do the work, and hands steady enough to use the instruments without tearing the fibers, we might unwrap them, bundle after bundle, and trace them from start to finish. We should then find that the largest bundles are the sixty-two

spinal nerves which pass through the sixty-two holes in the vertebræ; that as soon as each leaves the bone the dividing begins. Large bundles, from the cord, become smaller through their dividing, then still smaller; they hold anywhere from two hundred to twelve hundred separate fibers; they continue to divide and subdivide, so that fibers which started in the same bundle are soon widely separated. Often these fibers pass out of the wrappings of one bundle into the wrappings of another. They do this so constantly that these various bundles, as they grow smaller, are joined together like an intricate network. They twine and interwine, but not a fiber loses its way. Each tiny one of the millions that form that lacework of axons is a continuous path from some definite point on the skin, or from some muscle or gland, to some definite cell in a ganglion or in the spinal cord; and so long as no accident or wound or cutting separates the axon from its cell, the stimulus which each may receive will travel straight and true from the point of the body where that axon is stimulated to the center of the cell of which it is apart.



AXONS THAT END IN MUSCLE
(Highly magnified)

But accidents are frequent, and they teach scientists wonderful facts about these long-armed neurons. One of these facts is that axons are useful or not according as they remain connected with their own particular cells. Think of the burning baby. His axons of feeling and axons of motion were in good running order. He felt pain and could pull his hand away; but if a certain set of fibers had been cut across so that the connection was broken between the axons and their cells, no stimulus would have reached his brain. The baby could then have left his fingers in the fire until they were burned off without feeling the slightest pain. If, on the other hand, the smooth-root axons had been cut instead of those from the ganglion root, no



WHERE THE STIMULUS GOES. INTERTWINED NEURONS IN THE CORTEX

Notice the countless crooked dendrites and the many straight axons which run up and down (highly magnified). — After Kölliker

command could have reached the fingers from the brain. The baby would have suffered frightful pain, but he would not have been able to move his fingers back or forth to get out of trouble. His arm muscles would have had to come to the rescue of finger muscles and pull the hand away.

If both roots of that spinal nerve had been cut, the baby would not have felt any pain, neither would he have been able to move his finger. The burning would have gone on just the same, however. This was the case with the man mentioned in the first chapter, who could neither move nor feel. In his case both roots of certain nerves were useless.

The impulse which passes over an axon is always truthful if that axon is uncut and uninjured from end to end. But if damage has been done, strange reports may reach the brain. Old soldiers testify to this. One of these men lives near my home, and when we met the other day, he said: "Isn't it strange, my leg was cut off over ten years ago, but last night the heel of that foot itched and pained me so that I thought I should go crazy." "What did you do?" I asked. "Put a hot-water bag against the stump, warmed the thing up, and finally got relief." Of course he knew, as well as I did, that something was irritating the live ends of the axons that used to send reports from the heel to the brain, and that when the cells up there received the stimulus

they had no way of knowing that the axons had been cut in two, and that their extreme ends were no lower down than the knee.

The thinking and seeing part of my friend's brain did certainly tell him the truth. He knew that there was no heel there. Nevertheless, even that knowledge could not change the reports which faithful axons were bound to send to headquarters in the brain.

Something was out of order in their neighborhood, and they clamored for help until it came in the shape of a hot-water bag.

From all this it is evident that nerves and brain and muscles are pretty closely connected. But future chapters will show that the connection is even more intimate than we have yet imagined.

CHAPTER XII

NEURONS THAT LEARN LESSONS

As a child I had learned to swim soon after I learned to walk. Then, for years, there had been no swimming; but the chance came again and I had quite an experience. My bathing suit was on, my oiled cap in place, and I was ready to step down into the Mediterranean Sea from the narrow platform of a bath house at Leghorn; but, no matter how hard I tried, I could not remember just how the swimming was done. Should I strike out with one arm first and then with the other, or with both arms at once? Were the feet to start work at the same time? If so, how were they to go? What was to keep my head up? How in the world was I to keep myself from sinking?

All these questions came and went unanswered. Nevertheless my friends were growing impatient; I must join them at once. Slowly, therefore, I went down the steps into the water. Courage oozed away with every step, but there was no escape. At last I was far enough down to venture. I bent forward a trifle, stretched out my arms, felt the ripples go over my body,

dared to draw up one foot, then the other, and in an instant everything was working in proper fashion. . I was swimming out from under the canvas side of my bath house to join my friends — swimming as easily and as naturally as if I had been doing it every day for years.

The question just here is, How did it happen that I was able to swim like a fish after I reached the water, whereas before I went into it, I could not give myself so much as a hint about the way to do it?

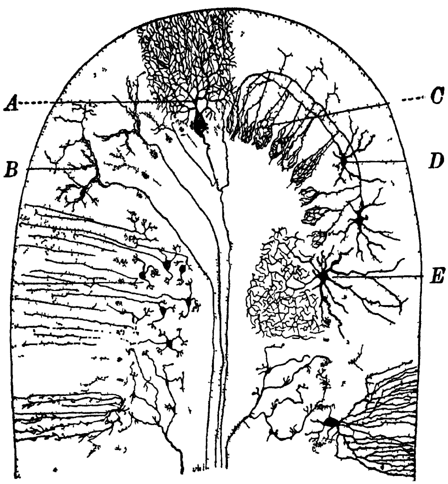
Many think that the answer to the question lies in the power of the unpretentious cerebellum. They say that my cerebellum saved my swimming reputation.

A famous scientist named Flourens once noticed that although a pigeon with a useless cerebellum does not suffer pain, it does, nevertheless, have the greatest difficulty in standing and in moving about. He saw that, when it moves, the muscles do not pull together in orderly fashion, but rather in an independent, helter-skelter way, each muscle, as it were, pulling for itself without reference to any other muscle, so that instead of walking, the poor bird turns one somersault after another in rapid succession.

Dr. Flourens also noticed that the less the cerebellum is injured, the less the pigeon is troubled with these disorderly movements, although even then it walks in a staggering, drunken way. It appears, however, that such pigeons may slowly learn to control their muscles

again, and that after a while they are able to walk and even to fly once more; but they never do it so well as before.

From these and other facts which they have gathered, men who study the subject conclude that the cerebellum is an enormous help to the cerebrum in the matter of controlling such muscles as we are able to guide by our own will power. They say that while the cerebrum is the commanding general of the nervous system, the cerebellum is the chief of staff — the one that helps take charge of numberless movements which we have learned to make through persistent, diligent practice. When we were babies and learned to walk, we thought about each step as we took it. If our minds were diverted, if certain special thinking neurons stopped attending to our footsteps, we tumbled down instantly. For weeks, and even for months, we hardly dared to walk alone.



CELLS IN THE CEREBELLUM
They guide our unconscious movements
A, *D*, *E*, cell bodies, *B*, *C*, dendrites — After Ramon y Cajal

To-day, however, after years of practice, we walk everywhere without giving a thought to any separate footstep. We even step so fast that we run and dance; we ride the bicycle and we swim. Indeed, we do all this so well, and we are able to think of so many other things while we use our feet and hands vigorously, that it looks very much as if they had become quite independent of their former neuron guides. This, in fact, explains the whole situation. Their movements have at last been put in charge of a different set of neurons. The happy part of this arrangement is that the particular neurons which do what we might call this underground managing for us are, as a rule, more trustworthy than those which help our conscious thinking.

There in Italy, for example, neurons in the cortex connected with my thinking had evidently forgotten all they ever knew about the way to swim; but when I trusted my swimming to certain other neurons that do my unconscious managing for me, they rallied to my rescue and showed what they could do.

The same law and the same power of the neuron holds good in other directions, too. What trained baseball player stops to think of each separate run and slide, how to hold the bat, how to pitch the curved ball, how to catch it? He simply takes his place to play the game; he trusts his trained neurons to help him, and he finds that almost unconsciously he makes the right motion at

the right instant; that he plays the game even better than he could tell another to play it. This proves that his unconscious neurons have learned their lesson thoroughly.

So too is it with the use of file or plane or saw, with playing the piano, the violin, the flute, and all other musical instruments. In each case the muscles seem to learn how to do independent work.

HE TRUSTS HIS CEREBELLUM

What swift penman thinks of the way to form his letters as he scribbles down his words? As I write just now I think of nothing but the idea I am trying to express and the words I wish to use. Yet there was a time when I gripped my pen until my fingers were stiff, and twisted my lips in droll contortions, as I struggled to make round letters and long letters of the proper size and shape.

In those days I could get no further than the letters themselves; but as soon as certain unconscious neurons were trained enough to take charge of the operation, the thinking part of my brain was left free to devote itself to the thing I wished to write about.

This is quite as true in still other lines of life. I know a fine young fellow, a freshman in college, who has lately taken up a noticeable practice. Often when he stands still, and even when he walks, he may be seen suddenly to straighten his neck and press the back of it firmly against the inside of his collar. Why does he do it? For the simplest of reasons. He believes that his head bends too far forward to be creditable, and he has made up his mind to put his neck muscles in charge of a new set of neurons. Every time he thinks about it, therefore, he sends imperative orders to those muscles. They straighten his neck promptly, and he gets his head up where it belongs. He knows that each pull in the right direction helps train a certain set of neurons, and that if he is able to persist long enough he will finally get them so well trained that they will end by making the muscles hold his head up all the time without any conscious thought about it on his own part, and that this will relieve his mind for other affairs.

When we are teaching neurons new lessons the time for encouragement is at the first sign that we are doing the desired thing unconsciously. For example, we may be training various sets of neurons to help us in definite ways — to walk like a soldier, to sit erect, to talk in a low voice, to hold knife and fork and spoon as we should, to recite the multiplication table, or to repeat a poem; and day after day we may be discouraged by the fact that as

soon as our own thought is off the subject we fail in our struggle; but, without warning, some day the moment for encouragement will come. We shall find that we have done the desired thing as we wished to do it, even while we were not thinking about it, and by that sign we shall know that we have reached the turning point. By being persistent a little longer, those particular neurons will have their lesson by heart, and the fight will be won.

This method of training is admirable for any set of neurons which we wish to press into service, but, even when we are not training them on purpose, our neurons often get trained in spite of our real desire. As an example, think of those which control the muscles of the face.

No human being would, even for a moment, lay plans to carry with him through life a face that proclaimed to the world that its owner was unkind, untruthful, regardless of others, greedy, vain, selfish, or silly. Nevertheless our faces are apt to betray the secrets of our character. Other muscles also help in doing the same thing.

On my veranda the other day I met a stranger who wished to find my brother. The man talked in low tones, was well dressed and courteous, and yet, when I stepped in to report him to my brother, I said: "Don't trust him for an instant. He is sly and insincere, probably a rascal." A few days later we learned that not a bank in town trusted the man. They said, "The fellow tries to look honest, but he cheats and lies whenever he

gets a chance." Of course the man himself would have been appalled had he known that when he was trying his best to make a good impression, his face was vigorously telling the truth about him even to utter strangers whom he met but for a moment. So it was, however, and so it always must be.

ABRAHAM LINCOLN BEFORE FACE MUSCLES HAD BEEN TRAINED

The face is controlled by muscles so numerous and so easily pulled about that they swiftly express any feeling that moves us.

Look at the large muscles of your arm when you are glad or sad. Do they tell any tales about you? Certainly not. Unless you contract them on purpose they show nothing but size and shape. But, when you are equally glad or sad, try to catch the expression of your face in the mirror; or look at the face of some one else who is happy, or angry, or suffering great pain. In every such case you will find that, unconsciously, the muscles tell a plain, straightforward story.

The truth, of course, is that almost every feeling we have may express itself in the face, and that each repetition

of any expression is one more lesson for the neurons of the muscles to learn. We might go so far as to say that these special neurons recite their lessons by the permanent expression which they give to us. The sad man, the worried man, the happy man, the hopeful or discouraged man, each has his own telltale face muscles; and a good student of human nature learns to read these faces almost as easily as if they were the pages of a book spread out before him.

ABRAHAM LINCOLN AFTER FACE MUSCLES HAD BEEN TRAINED

As might be expected, it is old rather than young faces that most easily betray their owners. I myself am old enough to know this from my own observation. I have seen a fair, smooth, child's face change little by little into the strong, courageous, unselfish face of a man who is ready and glad to do his duty whether he likes it or not. And I have seen another face, equally fair, equally smooth, and equally young, turn little by little into the dissatisfied, weak, and sneering face of a man who never serves any one but himself.

Without planning for anything of the sort, with no idea of what was happening to him, each of these men

has trained his neurons; and they tell the truth about him even when he might prefer to have them tell a different story.

All this is not a matter of being handsome, or of being plain to look upon, but simply a matter of having neurons which have learned to tell the silent history of the feelings and the emotions which have controlled a human life.

It is evident, then, that every young face is shaping itself to the expression it will have later; and that the time is sure to come when the tale of our inner lives will be told by the outward expression of face and manner. When that time arrives we may long to hide the facts about the history of our emotions. But we shall find that we cannot cheat the neurons. Instead, the story which they have been trained to tell will proclaim the facts about us whenever and wherever we show ourselves.

In this chapter we have laid bare four great laws of the neurons:

1. He who wishes to do any sort of muscular work easily and well, and so thoroughly that it cannot be forgotten, must, by diligent practice, put that special business in charge of its own set of unconscious neurons.

2. Neurons are often so quick and clever that they learn that which we would much rather they would not learn; and they proclaim the truth even when we wish them to hide it.

3. If we wish our neurons to declare that we are courageous, kind, and sincere, the only way to make them do it is by actually being courageous, kind, and sincere.

4. He who pretends to have desirable qualities when he really lacks them will find that, through the power of his neurons, in spite of his desire, he actually declares to those whom he meets that it is all mere pretense.

CHAPTER XIII

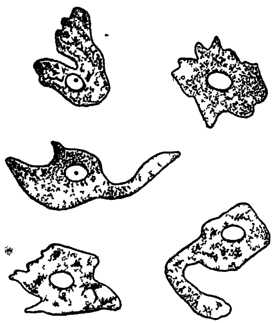
PHAGOCYTE AND ALCOHOL, OR FRIEND AND FOE OF THE NEURON

Scientists have known for a long time that red blood corpuscles are the oxygen carriers of the body; but for years they came to no conclusion about the occupation of his busy companion, the white blood corpuscle, the phagocyte,[1] "the devourer," as his name means in Greek. The mystery vanished, however, when Professor Metchnikoff, of the Pasteur Institute, Paris, turned his attention to the subject.

He took a healthy frog, carefully pricked some cholera microbes under his skin, and with his microscope watched the fate which befell them. The whole affair was easy to follow, for white phagocytes now flocked to the spot from all sides; they crowded close; each seemed to choose its special victim, and, drawing closer yet, laid itself up beside the enemy, stretched itself out as an amœba might do, and little by little wrapped itself about the doomed microbe.

[1] All phagocytes are white blood corpuscles, but there are also white blood corpuscles that are not phagocytes.

The phagocyte is really nothing more than a tiny round speck of protoplasm — merely a single cell like the amœba — but it captures its victims relentlessly. In vain the microbes tried to flee; their captors had surrounded them completely and held them firmly within their own bodies long enough to digest them. Instead of killing an enemy outright and throwing him aside, they rid themselves of him by swallowing him whole. Quickly hurrying to another, each phagocyte repeated the process, disposing of one microbe after another and growing larger with each captive.



SHAPES WHICH ONE PHAGOCYTE TOOK WITHIN A FEW SECONDS

When intruding microbes were small enough for it Professor Metchnikoff saw the phagocyte "swallow them in shoals as a whale swallows herring." Whereas, if they were too large for one to manage alone, several phagocytes would surround the same microbe and digest him in partnership.

In this connection it is interesting to know that a frog never dies of cholera. The reason is clear to us; frog phagocytes are so vigorous that they conquer cholera microbes before they have a chance to manufacture their deadly toxin and give cholera to the frogs. In the same direction Professor Metchnikoff

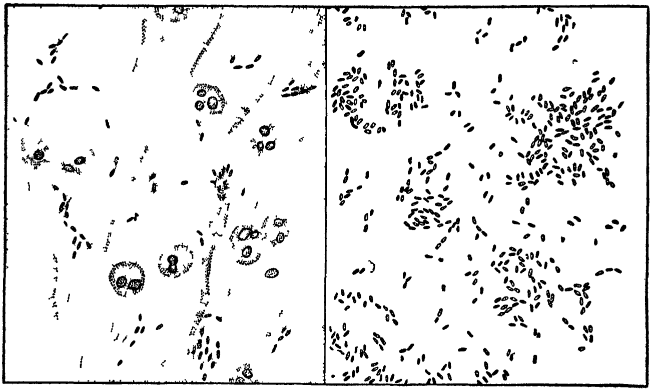
next discovered that pigeons cannot be made to take tuberculosis, for, here again, phagocytes seized the tubercle bacilli as fast as they entered the body and devoured them before any harm was done.

The work which the phagocyte does for the body is so valuable that we easily talk about this free-swimming, single cell as if it were a many-celled warrior with a mind of its own. In point of fact, however, and even though they do behave like friend and foe, there is no real enmity between the phagocyte and the microbe.

These small protectors of the body move from place to place in independent fashion. They spend most of their time in the blood; and in it they not only travel with the current but they also ignore that current entirely, and, like the salmon, swim up stream as well as down stream, as occasion may seem to require. At a moment's notice, also, they leave the blood and pass through any bodily tissue without the slightest difficulty.

Through Professor Metchnikoff's experiments and others since then, facts have been learned which help human beings. If our phagocytes are strong enough to destroy disease microbes for us, we shall be saved from certain serious diseases. If, on the contrary, our phagocytes are feeble, or if microbes enter our body in such swarms that there are not phagocytes enough to fight them successfully, the enemy will be victorious, the phagocyte will be defeated, and we shall be the victims

of any special epidemic that is traveling the rounds. Put two men into a town where cholera is working havoc; let one have more vigorous phagocytes than the other, and he will be the one more likely to escape with his life. Let measles or pink eye, whooping cough or influenza, break out in school, and those children with the most numerous and active phagocytes will suffer the



INFLUENZA MICROBES UNCONQUERED BY PHAGOCYTES

On the left, as they are found in the sputum of some colds, on the right, as they are raised in the laboratory

least. Let tubercle bacilli be thick in the dust we breathe, and those of us who own the best bodyguard in the line of well-developed phagocytes will be least likely to take the disease and suffer from tuberculosis afterwards.

The same law holds true even for less serious illness. When some one says, "I am so sensitive, I catch cold

at the least exposure," it is quite as if he said, " My phagocytes are wonderfully weak and inefficient, they are vanquished by all the microbes of influenza that enter my body." Another person says, " I never seem to take cold," and it is as if he said, " My phagocytes are such valiant warriors that they destroy every intruding microbe."

Yet the phagocyte is not merely an athletic policeman, a valiant soldier; he is also a scavenger and a street cleaner. With all his occupation he is never idle. Here and there through the body he hurries, always trying to remove waste matter and intruding microbes.

You cut your hand, or you run a sliver into your finger, and from every side phagocytes hasten to clear away the rubbish and to attack the microbes. If they can kill these mischief-makers as fast as they drift in, the wound will heal fast; if, instead, the phagocyte is too weak to slay the enemy, there will be a painful sore, slow to heal.

Hospitals are full of patients who prove this difference in their own bodies. One man has a wound that heals at once, and he goes home happy; another man stays in the hospital for weeks waiting for his wound to heal. The difference in recovery rests with the phagocytes of the two men. " Matter," or " pus," from a wound is the host of microbes and phagocytes that have been slain in the struggle. They are being washed away by fluids from the wound.

CHAPTER XIV

PHAGOCYTE AND ALCOHOL (CONTINUED)

The warfare within our bodies is a silent one. We hear no sign of any conflict; nevertheless, throughout our lives the strife goes on ceaselessly, and it makes all the difference between life and death to us whether or not our standing army of phagocytes is in good fighting trim.

In view of this fact our daily command to ourselves should be: *Protect the phagocytes from harm.* Every law of health is, indeed, so truly a law for their protection that he who follows health laws most strictly will at the same time be doing the most for his bodyguard. It is necessary, however, that we should know even more than this. Multitudes of cases prove the need.

In Glasgow, in 1848, a little more knowledge might have saved hundreds of lives. As shown in *Town and City*, Dr. Adams kept a keen eye on the death rate of his cholera patients, and he discovered that those who went without alcohol had a vastly better chance to recover than those who used it. Or, to put the facts more exactly, when those who used alcohol caught the disease

ninety-nine out of every hundred died; whereas, when those who did not use alcohol had the cholera, only nineteen out of each hundred died.

Knowing what we do about the effect of alcohol on the living cell, and knowing also about the discoveries which Professor Metchnikoff made in connection with cholera microbes and phagocytes, we understand at once the condition of affairs in Glasgow. Those men and women who did not use alcohol owned phagocytes that were vigorous enough to conquer the attacking cholera microbes; those other men and women who used alcohol had weakened their phagocytes to such an extent that when invading enemies came they were not strong enough to slay them.

Dr. Delearde had two cases which illustrate precisely this point.

A man and a boy were bitten on the same day by the same mad dog. The boy, thirteen years old, was bitten on the head and face, which are the very worst places for such wounds. The man was bitten on the hand alone — a much less serious matter. Both victims were taken to Dr. Delearde, and he gave each his most careful treatment; but the man, who should have recovered, died of hydrophobia, and the boy, who might have been expected to die, recovered. The only difference in the two cases seemed to be that the man used alcohol and that the boy did not use it.

This led Dr. Delearde to look into the subject still farther. As usual, when experiments have to be made, he took two sets of rabbits; to one set he gave a little alcohol each day; the other set received no alcohol. He then vaccinated both sets to try to prevent them all from taking hydrophobia. After they were supposed to be proof against the disease, he put the poison of hydrophobia into their blood and was not surprised at results. Those rabbits that had had alcohol took the disease as easily as if they had not been protected against it; whereas the poison had no effect whatever on the rabbits that had not had alcohol. Evidently their phagocytes had served them well.

In looking back to the seventeenth chapter of *Good Health* we now understand one reason why Bum and Tipsy suffered so much more than Nig and Topsy when the epidemic of dog illness raged in Worcester. Alcohol had weakened their phagocytes to such an extent that disease microbes had the upper hand from the start.

Just here we stop to review a point which was brought out in the twenty-second chapter of *Town and City*. When death comes from disease microbes it is not the microbe itself, but the poison which the microbe gives off while it multiplies, that does the mischief. Each disease microbe has its own special variety of poison — of toxin — and fevers of one sort or another simply show

that a fierce fight is going on between microbes that are producing poison and phagocytes that are devouring the poison producers.

Over and over again, in many microbe diseases, death comes from the fact that one set of neurons or another has been poisoned or paralyzed by the toxin which the microbes have produced. It is here, then, that the connection between phagocyte and neuron steps in. By destroying the microbe which makes poison, the phagocyte protects the neuron. Very often, therefore, the battle between phagocyte and microbe is a battle in behalf of the safety of the neuron from the poison produced by the microbe.

This is particularly true in that dread disease, pneumonia; and sometimes a doctor helps science by following the record of the battle. From time to time he draws a drop of blood from the arm of his patient and examines it under the microscope for phagocytes. He knows that according as the numbers of these protectors increase or decrease, so also is there prospect of life or death for the sufferer himself. The normal count is from five thousand to seven thousand in each cubic millimeter, and it takes sixty-one cubic millimeters to make one drop of water.

When, by his examination of the blood, the doctor finds that the number of phagocytes is mounting steadily upward from ten to twenty thousand, from twenty to

fifty, and even to seventy thousand, he takes courage. He knows that "the body is rallying its forces to battle with invading hosts of microbes, and that, if the fight can be kept up long enough, the victory will be won."

Dr. Moorhead of Edinburgh, Scotland, was talking once about the treatment of pneumonia, and he said, "If I can get a patient who has had no alcohol, I have very seldom any doubt as to the result of that attack of pneumonia, and I find that it is never necessary to give alcohol in those cases at all; in fact, patients do better without it." There are doctors who would not agree with Dr. Moorhead in this matter. Nevertheless it is true that, even as a medicine, all our best doctors, in our best hospitals and out of them, are, in these later years, giving vastly less alcohol as a medicine than they gave in former times. They are understanding better and better the nature of the effect which it has on the life forces of the body.

Scientists claim that phagocytes are being manufactured constantly in certain lymph tissues, and that when a special need comes, when a wound is made in the flesh or when disease microbes multiply in the blood, then the tissues send out new regiments of soldiers by thousands and by millions. And it appears that, from the start, even the youngest among these soldiers are ready to risk their lives in immediate service.

Nevertheless, although a young and healthy phagocyte may be so vigorous as to be like a Samson among his microbe enemies, still, as we have seen already, there is a way to defeat and destroy him. Let one of these young phagocytes be launched into blood that has alcohol in it, and what is the result? Does he gain courage for the fray? Does he scurry off to the battle ground with the greater strength?

Quite the contrary; his fate is now sealed, for that alcohol overcomes him as a subtle power more deadly than any microbe. It is a toxin which will dull a phagocyte or paralyze him utterly, according as there is more or less of it in the blood.

A trace of alcohol does not rob phagocytes of all power. They may still be strong enough to reach the scene of battle; they may even wrestle with a microbe on the way there; but instead of being strong enough to conquer, they are now weak enough to be conquered. When that condition exists disease microbes find themselves free to carry on their business of toxin manufacture without interruption.

From beer and hard cider, all the way through to gin and brandy, each drink harms the phagocyte with its alcohol, and the more alcohol the drink holds, the more is the phagocyte damaged by it. The table on the following page shows what per cent of alcohol is found in certain drinks.

Alcoholic Percentage of Common Drinks

Beer	3–5
Hard cider	4–5
Ale	7–8
Wines of different kinds	7–20
Champagnes	11–18
Brandy	30–55
Whisky	50

In view of this power of alcohol, we realize that when a man raises his glass cheerfully to his lips and drinks to the health of his king or his friend, he drinks, in truth, to the success of disease microbes in his own body; while, at the same time, he drinks to the death of his own most faithful bodyguard.

If the owner of a castle had drugged his watchmen on the towers, had bound his soldiers hand and foot, had killed his bodyguard, would he have the right to be surprised when he found his worst enemy within the gates? If that enemy robbed him, or beat him cruelly, or killed him through slow torture, would any one be to blame but the owner of the castle himself?

Protect your phagocytes from harm and they will protect you in time of need. Weaken them through the use of alcohol or any other poison, or through neglect of the laws of health, and you will be as a man who has drugged his watchmen on the towers, bound his soldiers hand and foot, and killed his bodyguard. He who has done all this is sure to suffer when the enemy comes.

CHAPTER XV

TIRING THE NERVE CELL

Several years ago the restless little bird that is a trial everywhere, the bird that every city feels obliged to destroy — the small, brown English sparrow — gave science quite a lift through its brain cells.

Dr. Hodge chose birds for his investigations because, taking size and weight into account, they probably do more work in a single day, are more active, than any other vertebrate on the face of the earth; and he wished to see whether the cell part of a neuron is changed at all when a bird works so hard.

A SPARROW, WHOSE BRAIN CELLS GROW WEARY WITH WORK

He made two examinations every day: one in the morning, to see how the neurons looked after a long night of rest; another in the evening, to see how the neurons looked after a long day of work. By condensing a good deal, I make two extracts from the record which Dr. Hodge kept.

Experiment I. Made at the close of a cold, blustering snowstorm in December. Sparrows under cover during the storm; at its close, out in force hunting for food. Spinal ganglia examined at seven in the morning, after a night of rest, and again at 5.30 P.M., after a day of food hunting. Shrinkage 54.3 per cent.

This means, of course, that the cells of the neurons that formed the ganglia were very much smaller after the work was done than before it was begun.

Experiment II. February 17, a rainy day. Birds had had no exercise; had stayed close "in the dense cover of the pine trees over my window"; had "spent the day scolding and chattering at a great rate." No flying done. The microscope showed no sign of fatigue in the spinal ganglia, but clear signs of fatigue in the nuclei of the cortex of the cerebrum, "as though, while confined by rain, the little birds had kept up a deal of thinking."

Swallows also made their contributions to these important investigations. It was well to test them, for no other bird is more active than the swallow. As Dr. Hodge says:

Its food consists of insects taken entirely on the wing. Quick, vigorous, purposeful, careful in all its actions, it must require an enormous amount of nervous energy to coördinate its countless movements for a long summer's day. There is nothing lazy or stupid about the swallows. When their work is done they play games and fly races; and, with all the energy required for flying, they have enough left to do no end of talking. At one hundred miles an hour for ten hours, — and I have observed them as early as five o'clock in the morning and as late as eight at night, — a swallow might cover a distance of one thousand miles in a single day, and day after day.

These swallows were tested morning and evening, and Dr. Hodge was not surprised to find that, instead of cells that were tired in the cerebrum, it was now cells in the cerebellum that were changed. We have no difficulty in understanding this, for we know that the cerebellum helps the cerebrum in the matter of making muscles pull together, in walking and running, for example, in dancing and swimming. Naturally, then, flying is helped too. "And where could be sought an instance of more delicate manipulation of muscles than must be required to drive the wing of a swallow as it flits and whirls and balances and wheels and darts the whole day long!" No wonder the cerebellum of the swallow showed the traces of its work! The protoplasm is often vacuolated, that is, filled with clear spaces, as though particles here and there had been dissolved out.

A Swallow

"It flits and whirls and balances and wheels and darts the whole day long."—Hodgl

In each one of these examinations the principal change was in the innermost center of each cell—in the nucleus itself.

But what creature is ever busier than a bee in honey season! His brain, therefore, should teach quite a lesson, as indeed it did. Dr. Hodge made the test and found

that each cell which was taken from a bee's brain in the morning had a plump, round nucleus, whereas each cell taken from some other bee at evening — after a hard day spent in carrying loads of honey — was much smaller, much more jagged and irregular.

Now that which happens to the neuron of one creature is accepted by scientists as a sign of what happens to all of us who are supplied with neurons; for, whether covered with feathers, fur, or silken garments, we are the kindred of each other. Some of us do surely have more neurons than others; some of us also think we are more intelligent than our feathered and furred fellow-creatures; but the same treatment affects their neurons and ours in the same way. Through their neurons they feel pain, through them also they move their muscles, while fatigue affects them and us in similar ways.

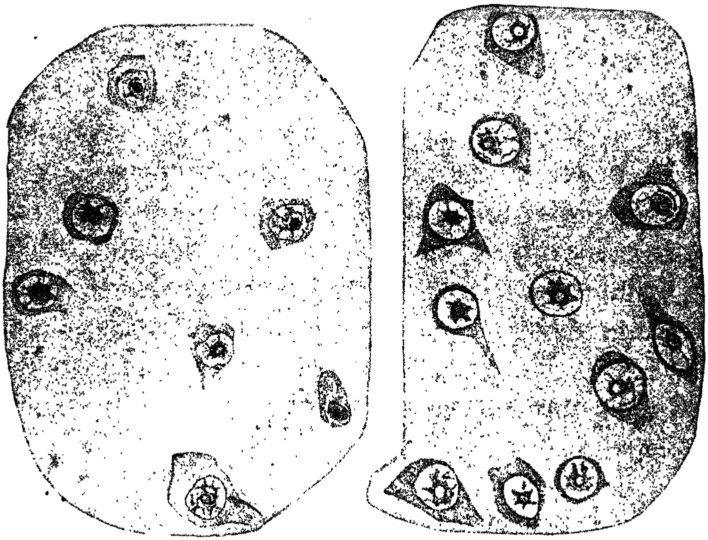
Dr. Hodge decided that, for us all, it is the cell and not the fiber of each neuron that gets tired; and that the greatest change is in the nucleus at the center of each cell. The case for one and all can be stated in two sentences:

1. Before exertion the nucleus of the cell is large and round, smooth and regular.

2. After prolonged exertion the nucleus is small, jagged, irregular. It has lost substance and become crumpled. Dr. Hodge also learned, by other experiments, that when tired cells have a chance to rest,

the nucleus begins at once to grow larger, rounder, and more regular again.

These different facts throw a flood of light on all the laws of fatigue and rest. Through them we come to the



A B

CELLS FROM THE CORTEX OF A PIGEON

A, cells examined at the close of the day (notice the outline about the nucleus, it is somewhat irregular and shrunken); *B*, cells examined in the morning (notice the smooth, full outline about the nucleus)

conclusion that when the African quails were exhausted from muscular work, and when the professors in Turin were tired out from mental work, each one had tired nuclei at the center of certain sets of neurons. We see then why fatigue and good work do not go together.

If such a thing were possible, the sight of our neurons when we are tired would convince us that a lean and jagged nucleus can serve its neuron master no better than a lean and jagged horse can serve the farmer. Each will do the best it can for his owner, but in both cases the wise master will try to put his servant in good condition before he asks him to do another piece of hard work.

Let no reader think that this chapter teaches any lesson against vigorous exercise. On the contrary, let each of us remember that neither bird nor man is harmed by drawing on the power of his nuclei unless he carries the matter too far. Fatigue is good for us if we balance it by rest. This will be made plain in Chapter XVII.

CHAPTER XVI

THE TOXIN OF FATIGUE

One of the great questions in life is, How shall we rest in such a way that our shriveled nuclei may grow plump and vigorous again?

My nephew was talking about this last evening, and he said: "I can work the thing out perfectly. When I 'm too tired to go on with geometry I pull out my Latin and begin at that." "Doesn't your tired geometry head hinder good Latin work?" I asked. "Not at all," he answered. "It goes along as fine as can be, and when I 'm tired of studying in general, all I have to do is to go off to the ball ground. Studying never gets a fellow too tired to play you know"—and he laughed as if even the thought of it were a great joke. "Then, when I 've played awhile I 'm ready for study again. So you see, it 's a great scheme." I agreed with him, and I thoroughly believe that change of occupation saves multitudes of people from getting too tired. Nevertheless, there is such a thing as being so tired that nothing can be done well in any direction, so tired that no change of occupation brings relief.

Even children prove this over and over again for themselves. Once it was on the Hawaiian Islands. A thirteen-year-old boy had ridden thirty miles on horseback from Honolulu to Waialua, and when he reached the narrow river there he was so tired that his uncle's home just beyond it looked as beautiful to him as the Land of Canaan looked to the Israelites in the wilderness; but when he reached the doorstep and slipped down from the back of the horse he found himself so stiff and lame that he could hardly walk.

If he had known about neurons in those days, he would have been very sure that every nucleus in every neuron of his body was hopelessly shriveled, for at that moment he was too tired for any occupation whatever. Running would have had no charm for him, and hard study would have been out of the question. Soon, however, what seemed a miracle came to pass. A comfortable old Hawaiian woman spent half an hour in giving him the wonderful "lomi-lomi," the massage of the land. She worked her hands and fingers through his tired muscles from head to heel. She kneaded and rubbed and twisted each muscle that he owned; and when she left him, he was as rested as when he started from Honolulu in the morning. He was ready for running or swimming, for study or play in any direction.

At that time he understood nothing about the reason for the change, but now he accepts the whole as a

matter of course. He has learned the astonishing fact that there is such a thing as being poisoned by fatigue, and then such another thing as getting rid of this poison. It seems that even as microbes damage our blood by the toxins they produce,[1] so also does exercise of neuron

A HAWAIIAN GIRL GIVES "LOMI LOMI"

and muscle produce waste material which is a toxin — a poison — to the body. Scientists call this poison the toxin of fatigue; and well they may, for they have taken blood from an overtired dog, have put it into the body of a rested dog, and have seen the rested dog grow tired

[1] See *Town and City*, Chapter XXII.

at once. They have found that the larger the dose, the greater the fatigue of the one who receives it.

Such a discovery as this means everything to each of us. It not only supplies us with interesting facts to think about but it also points out the road that leads to one line of cure for fatigue. It seems to say: "Dislodge, destroy, drive off the products of waste that come through exercise of body or brain. They are a poison to you, and the sooner you get rid of this poison of fatigue the sooner will you be rested."

There, then, we stand, face to face with the argument for "lomi-lomi." We have arrived at the clear reason why massage is the quickest, most practical way of dislodging and driving off this special kind of toxin. Still, the full force of the argument will appear only after a little more testimony from the ergograph.

Dr. Maggiora was interested in the subject and, in order to make experiments about it, he tested himself on this machine again. First he used an unmassaged, rested finger, pulling up, as before, the six and a half pound weight once every two seconds. Twenty-four hours later he massaged this same finger for three minutes and pulled the same weight again. He repeated the experiment many times and learned that even a rested finger will do about twice as much work after it has been massaged as before the massaging is done. This was quite a revelation.

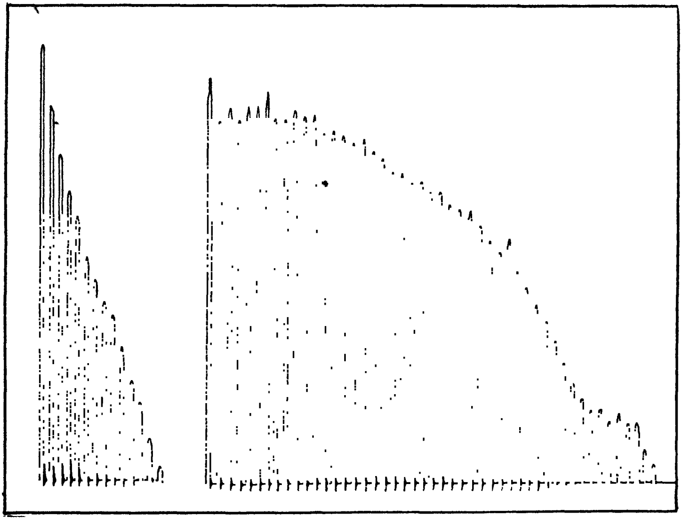
Dr. Maggiora's next question was as to whether massage would help tired neurons as promptly as it helped those that were not tired. He therefore made other experiments.

One day, after walking ten miles, he tested the middle finger of each hand and found that it could do only about one quarter as much work as before he started on his walk. He then had his hands and arms massaged for about ten minutes and was delighted to see that he could now give the normal pull again.

This was especially surprising, for, as he says, it would have taken two hours of solid rest to make it possible for him to do such pulling as that after such a walk. Facts of this sort explain why athletic trainers have so much to say to their men about massage. They know that after vigorous exercise massaged legs are far more ready for another struggle than unmassaged legs.

At another time Dr. Maggiora made ergograph tests after a sleepless night. A small, feeble pull was all he could manage when morning came. But ten minutes of massage made everything normal. So, too, after hard examinations. Twenty medical students kept him busy one day for five hours. He was then so exhausted in mind and body that his pull was only about one fifth of what it was when he was rested. Half an hour later, after ten minutes of massage, he could do full work again on the ergograph.

At this point comes in an important side light. Dr. Maggiora wished to learn whether or not blood itself has anything to do with these remarkable cases of transformation. Accordingly he had the large artery of his

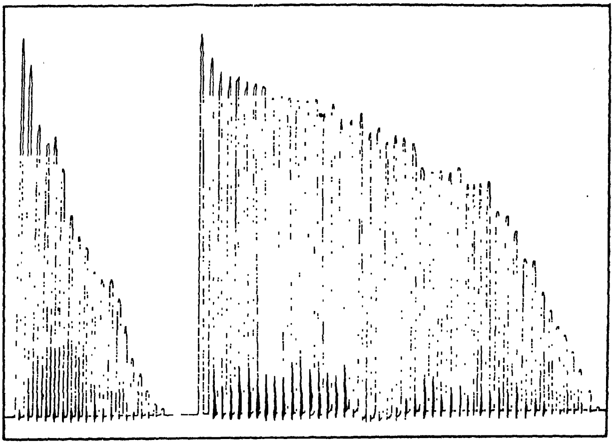


THE FEEBLE PULL AFTER A TEN MILE WALK, THE STRONG PULL AFTER TEN MINUTES OF MASSAGE

arm firmly pressed for five minutes. This kept the blood from flowing into his fingers. Even while the blood was held back in this way, he used the ergograph and found that it behaved as if the finger were very tired. He now had that finger massaged, still keeping the blood out of it, and tried the ergograph again, but there was no improvement whatever.

This completed the case. Dr. Maggiora now understood three reasons why massage helps the neurons:

1. It makes the blood move faster.
2. Swift-moving, fresh blood carries the toxin of fatigue along with it, and it is destroyed on the way round.
3. When the toxin is out of the way the neuron can compel the muscles to do better work.



THE FEEBLE PULL AFTER A SLEEPLESS NIGHT; THE STRONG PULL AFTER TEN MINUTES OF MASSAGE

With all these facts before us, we are not surprised to hear that massage, when it is correctly given, rests tired brains and tired muscles even more promptly than sleep itself.

Those who use either brain or muscle hardest and those who wish to get the most help from their neurons ought to know that the nuclei themselves have no direct way of letting us know when they are getting too much shriveled for our best good. Fortunately, however, the toxin of fatigue makes us feel so exhausted that we are led to stop work before the uncomplaining nuclei are utterly worn out.

Rest, then, would seem to be a matter of getting rid of the toxin of fatigue, and also of giving the nuclei a chance to regain their vigor.

CHAPTER XVII

NEURONS THAT REST WHILE WE SLEEP

There are times when a quiet rest in bed may be even better than massage.

A friend of mine knows this. She has a small son who studies and plays and works with such tremendous energy that, every now and then, he is worn out and shows it. At such times he is cross and irritable, losing his temper at a moment's notice.

When that state of affairs arrives and continues for several hours his sensible mother says to him very quietly, "Your nerves are tired, my boy, you must go off and give them an hour's rest." She does no scolding, and the boy understands that the rest is simply a matter of tonic for the neurons, not a punishment. He very much objects to going to bed by daylight, but there's no escape; so he goes to his room, covers himself up in bed, and stays there for the required length of time. Sometimes he sleeps, sometimes he lies out straight, wide-awake, but always when he appears again he is happy and rested and thoroughly good-natured. The quiet has restored him.

It takes about an hour for this kind of tonic to work with this particular boy, and the dose has to be given once in a while, just because his intelligent mother knows that tired neurons and crossness go together, and that resting the one will cure the other.

The same law holds good for other children, as also for grown people of every age. Let us bear this in mind, and act accordingly. When we are cross, knowing what has probably happened to our own neurons, let us give them rest. Let us remember that each of us is master of his own living machine; that we can keep it in order or put it out of order by the way we treat it; and that it will serve us well or not, according to the treatment it receives.

In 1907 Senator LaFollette was so sure that over-taxed neurons often explain railroad accidents, that he brought the subject to the attention of the Senate of the United States. He wished to show that engineers and flagmen often have to go too long without resting their neurons, and that human lives are endangered thereby. He cited case after case to prove this. I quote a few of these cases which he took from official reports.

1. Collision. Engineer dozing; seventeen hours on duty; only six hours' rest preceding his call to this service.

2. Collision. Train not under control. Hours on duty, forty-two.

3. Collision. Signal man went back to flag; fell asleep; twenty hours on service.

4. Collision. Engineer dozing; twenty hours on service.

5. Collision. Engineer mistaking signals; twenty-seven hours on duty.

Each one of these collisions preaches the same sermon, and in every instance the text of the sermon is: "When the nuclei of the neurons are already shriveled by fatigue, it is perilous to tax them further; for overtaxed neurons cannot be trusted in responsible positions."

There are times, however, when something besides fatigue and long hours makes us sleepy. To save repeating on this subject, turn to the chapters on sleep in *Good Health;* the present chapter has only space enough for the reasons that explain those chapters.

Why does monotony put people to sleep? Why do we feel sleepy in certain large gatherings? The answer is easy. We are not interested in what is going on, and the brain does not exert itself; without exertion it calls for little blood; without blood it grows pale; a pale brain wants to sleep. We feel sleepy then because the brain lacks blood. But let something happen in the church where various people, young and old, are feeling sleepy. Let a dog run up the aisle, or let a woman faint in the next pew; let anything be done that will compel the brain to call for blood, and sleepiness vanishes in an instant.

Impure air encourages drowsiness, but the speaker who can keep the brain of his hearer active will keep it awake in spite of the air.

A sleepy boy is trying to keep awake in a quiet room, when suddenly his excited brother and sister rush in, eyes sparkling, cheeks glowing, tongues moving fast, and in no time that sleepy boy is as wide-awake as they are. Why? Simply because the talking children set his brain to thinking; thinking meant exercise; exercise meant more blood to the brain, and no one sleeps easily in that condition.

It is, indeed, just because of this that we find people at the other extreme of perplexity. They cannot sleep. For them every device is necessary to drive blood out of the brain — a noiseless room, comfortable bed, pillow of the right size, fresh air, and a mind free from worry of every sort. The following rules may also help.

1. Enough exercise by day to secure muscular fatigue by bedtime.
2. A restful evening without mental work or excitement.
3. A hot foot bath, or a hot-water bag at the feet to increase the flow of blood in that direction.
4. A cold-water bag on the head to decrease the call for blood up there.
5. A hot bath, lasting a few moments, to draw blood to the skin.

6. A cracker or two eaten to compel the stomach to call to it some of the superfluous blood from the brain.

7. Monotonous thoughts and sounds.

To explain several of these points we must remember that we may reduce the amount of blood at one part of the body by doing that which will make it go elsewhere. *Good Health* shows the need of monotony, and now we discover the reason for it. Quietness and monotony subdue the active brain and drive the blood away. Anything, therefore, that requires little thought — anything that keeps the mind from traveling at a brisk pace to the ends of the earth and back again — is a move in the right direction.

Perhaps each person must discover his own road to the blessed land of sleep. I discovered mine long ago quite by accident. And this is the way I travel upon it. I close my eyes and tell my eyeballs to stand firm, not allowing themselves to move from side to side as eyeballs are apt to do on their way to sleep. With my eyelids down, I then look straight ahead into space. I know that if I am patient I shall soon see some unexpected, lovely picture. I have no notion as to what the picture will be, but I know that something will come, and I wait with expectation for it.

Soon there seems to be a clearing in the darkness, as if I looked into an open, white sky, and the clouds roll

away in spots. Sometimes I see no large space, but only a bright point which moves across the range of my vision. I continue to gaze steadily, for it is in this open space that the picture will appear. Then suddenly I see it — the side of a rustic house covered with roses, or a slender waterfall ending in spray, or a great stretch of ocean ending in sky.

The picture is always simple and small and it passes away quickly; but in connection with it comes my sleep. And that is the discovery. While I am holding my gaze steady, while I am waiting — sometimes before the first picture arrives, sometimes after I have seen one or two — suddenly, without a moment of warning, I am fast asleep.

This, then, is my path to the land of dreams. But whatever the road we take, our neurons are not wholly inactive while we tarry in that land. Some birds sleep standing on one leg; I have seen them do it. It is neurons that take care of the lifted leg and see that it stays up. There are soldiers who sleep as they march. There are children who talk in their sleep. I know a woman who sang once as she slept. And none of these acts could take place without commands from the neurons.

Other neurons never rest. Through their help heart and lungs, stomach and sweat glands, liver, and all the other organs of the body work as well when we are asleep as when we lie awake or walk about.

Perhaps we ask, "What is it then that goes out of business, what is it that rests when we call ourselves asleep? Scientists answer the question by saying that the space between sleeping and waking is very hazy; that the border line is dim; that certain neurons are busy in our dreams; that other neurons keep the organs of the body active, but that the part of the brain which most truly sleeps is that part which is the basis for our seeing, our thinking, and our feeling.

Evidently, then, sleep is the rest time for our cortical neurons. It is for the sake of what they must do for us when we are awake that we are careful to give them definite hours of sleep. In a way it is a selfish matter. We treat them well at night because we wish them to treat us well by day.

As a rule, human beings need to sleep according to their age and according to their vigor. Bear in mind two points:

1. The younger the child, the more sleep does he need in order to secure good service from his neurons.

2. The weaker the person, the more sleep does he need.[1]

Whenever we are tired we prove within ourselves that the cells of the body have been breaking down faster than they could build up. Exercise breaks them down, whereas rest, especially during sleep, builds them up

[1] The hours of sleep for different ages are given in *Good Health*, page 54.

again. Every living creature should manage to keep the two conditions balanced. Those railroad accidents occurred because the balance was not kept.

He who wishes to do good work should rise in the morning with a feeling of being rested. The man or woman or child who gets up tired and goes to work in that condition is losing the balance of things; he is getting too little sleep; he is doing all he can to wreck the engine that pulls his train, and he will probably succeed in doing it.

CHAPTER XVIII

OUR SYMPATHETIC GANGLIA

In the spring of 1907, at an athletic meet for the public school boys of New York City, we watched the relay race. Four boys started abreast, and as they ran they seemed to command legs, feet, and bodies to strive to their utmost.

Every muscle responded. The boys fairly flew over the ground until, with outstretched arms and straining fingers, they touched the straining fingers of the outstretched arms of other boys who were to fly across the next curve of the huge, oval track.

At the end of the flight one of the boys fainted away for a moment and fell into the arms of his friends. Why did he faint? Because leg muscles, arm muscles, body muscles had, as it were, robbed the brain of blood. They had needed so much for their own work that they clamorously demanded it, and certain neurons had met the demand by issuing command after command to the heart to work faster and harder.

The heart had no choice. It had to obey. In the meantime, however, the neurons which govern the heart were

getting overtired. I suppose the nuclei were shriveling, for the results proved that the commands were growing fainter and weaker. The heart was doing all it could, but even with its utmost endeavor it finally failed to pump as much blood into the brain as certain neurons up there needed. They accordingly had to stop working

THE RELAY RACE
Each hopes to win

for lack of it, and at that instant the boy became unconscious. He fainted. When this condition overtook him his brain was probably even paler than that of the pigeons that were exhausted by their flight from Bologna to Turin.

The point to bear in mind just here is that, as a rule, a person who faints during exercise proves that he has

not been properly trained. The trained runner does not faint, for a healthy heart, like any other part of a healthy body, learns through practice to do the work which is required of it.

Exercise is all-important for each of us, but when it is so violent that a set of untrained neurons has to be overworked, it becomes harmful and not helpful.

An overworked bicycle rider is the one who is most apt to have trouble with his heart. His thinking neurons are able to force the neurons which control his heart to work so persistently that, in time, the heart is over-stretched; that is, it has become too large to do faithful, everyday work. The man is then said to have "heart trouble."

Pause just here and test yourself in two ways. First, try with all your might to make your heart stop beating. Try to prevent the great arteries from expanding and contracting as the blood surges through them in pulses. See whether, by thinking and willing hard enough, you can prevent your sweat glands and oil glands from manufacturing salt water and oil. Will your stomach obey you when you command it to stop digesting your food?

Now turn the tables. Say to your heart as it pounds steadily along: "Beat faster. Beat faster. You must beat faster." Will it obey you? No; it goes neither faster nor slower by the fraction of a second. Your commanding neurons and your heart seem to be as

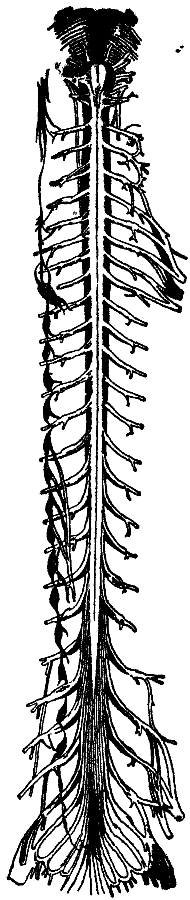
independent of each other as if they belonged to different bodies and lived in different worlds.

Nevertheless, as we all know, life itself depends on this beating of the heart. We know that whenever it stops and fails to start again we shall die, but from year's end to year's end we think nothing about it. At night we lie down to sleep with no anxiety lest the steady pulsing should cease. By day we run, dance, dive, swim; we play leapfrog and football; we walk on our hands and turn somersaults, knowing all the while that the heart is affected by every move we make; but, through all that we do, we seem also to know that somehow the body has an arrangement for controlling its most important life machinery whether we pay attention to it or not.

And so it has. Up and down on each side of the backbone is a chain of ganglia which holds more vital power, perhaps, than any other part of the nervous system. It seems to be nature's device for relieving the brain—a device for keeping the vital machinery in running order whether the owner of the machinery gives heed or ignores it.

There we have it then! We have come upon the mystery of the so-called sympathetic nervous system; the mystery of the neurons and ganglia which take charge of internal, bodily affairs—neurons which do their faithful work whatever our commands to them may be. This work is in charge of what is called the

sympathetic nervous system. So far as location and arrangement are concerned, it is not very difficult to understand the facts about this system, and the following outline will give them as simply as possible.



SPINAL CORD WITH SPINAL NERVES

On the left are a few sym pathetic ganglia joined by their rope of axons

1. Forty-nine ganglia unite to form the main part of the sympathetic nervous system. These ganglia belong together as a complete set. Twenty-four lie on one side of the backbone, twenty-four on the other side, and one lies in front of the very last bone of the back.

2. Each of the forty-nine ganglia is connected with its neighbor above and its neighbor below by what might be called a rope of axons.

3. This string of ganglia, held together by an axon rope, seems to hang like a loop, with the backbone as a pole in its center.

4. The neurons of the different ganglia send axons off to definite parts of the body — to

heart, stomach, liver, and elsewhere. At these different places the axons are so closely woven together that they form a network called a plexus; small ganglia are interlaced with each plexus.

5. One very important plexus is near the heart, another near the stomach.

On the street the other day my four-year-old friend suddenly bent his head forward and thumped it into the stomach of an elderly man who came that way. The boy was surprised when the old man bent himself double and almost groaned aloud, for the child himself knew nothing about the plexus of axons near the stomach, neither did he know that wherever axons are thickest there it hurts most to be punched. The boy's brother, fourteen years old, understood the situation perfectly. He thought the man really needed to groan, "because," as he said, "you see it hurts awfully to be thumped in your stomach like that."

Each ganglion receives some axons from the spinal cord; and this shows that even though we cannot control the neurons of the sympathetic ganglia by our will power, they are, nevertheless, working hand in hand with the neurons of the brain.

CHAPTER XIX

THE WAY TO GOVERN THE GANGLIA

If you really wish a faster heart beat, spend two or three minutes in taking swift, vigorous exercise of one sort or another. Either chase a car down street, race upstairs, or go through some set of energetic gymnastic exercises; then count your pulse. You will find that you have sent it bounding upward from seventy to one hundred and twenty or more throbs a minute.

This test will prove that although you cannot increase your pulse beat by giving direct commands, you can still get the result in an indirect way. Your thinking neurons can set muscles to work; these muscles call for blood; this call compels the ganglia which control the heart and blood vessels to issue prompt orders for rapid work. They force the heart to go to work with a will, expanding and contracting, contracting and expanding, with every throb you feel.

Other parts of the body are constantly influenced in the same way; that is, certain sets of neurons seem to hold the whip hand over certain other sets, compelling them to do what otherwise they would not have done.

This fact explains the unconscious service which we often get in various other directions.

When I think of ice cream and candy, of peaches and strawberries, for example, the neurons of the salivary glands are so affected that they set the glands to work and my "mouth waters." When I am hungry and think of eating, the neurons of the stomach compel gastric juice to flow. The work of digestion is in this way helped by the mere fact of being hungry. Thus, in one direction and another, entirely without our knowledge, different groups of neurons toil for our welfare.

Every day, by still other methods, and without our planning for it, the mind governs the ganglia like a lordly tyrant.

Such was the case with a woman who suffered because her baby suffered. Dr. Carpenter writes about it. This woman was watching the child at play; saw the tiny hand on the sill of the open window; saw the heavy sash fall with a crash and cut off three baby fingers; and at once, while the child screamed, she herself suffered great pain in her own hand. The doctor did what he could for the baby, then turned to the mother, who was now moaning and groaning with pain. He found that three of her fingers were red and swollen; and, strange to say, these very fingers were the mates of those the baby lost. They looked and felt as if they too had been crushed.

The explanation of the wonder runs something like this. When the woman saw the sash crush the baby's fingers, her great sympathy affected the sympathetic ganglia on the instant, and, through their axons, they compelled the blood vessels of her own hand to behave precisely as they would have done if they themselves had been bruised by the window sash.

It is clear, then, that in a remarkable way sympathy and fright may influence the ganglia that control the heart and the blood vessels.

For the sake of investigating the matter still further, and finding out whether or not feelings have anything to do with the kind of work which the stomach will do, certain scientific men pressed a friendly cat into service. First they let her swallow a chemical substance which made it possible for them to study the outline of the stomach itself whenever they used the X-ray on it. This stuff was entirely harmless, and gave the cat no discomfort whatever.

Next they gave her a delicious meal of cat food. And, by the light of the X-ray, they saw that the stomach went to work on the food in the good old-fashioned way. Now, however, came the unpleasant part of the experiment. These men needed to know whether or not the stomach would keep at work even if the mind of the cat were excited and worried. They therefore made the test, and they discovered that, so long as she was worried,

excited, unhappy, and full of discontent, the stomach was inactive. The food stayed in it undigested.

The men now stroked the cat into purring quietness, used the X-ray once more, and were delighted to see that the stomach of the contented creature was again doing as faithful service as if it had never stopped its work.[1]

This proved a point which thoughtful people have always suspected — that quietness and happiness aid digestion quite as much as unquietness and unhappiness retard it.

A friend of mine says that many a time when he was young he had the cat's experience on his own account. He was quick-tempered, nervous, and excitable, and he found that if he lost his temper while he was eating, or if he even became unpleasantly excited, he immediately felt as if all the food in his stomach had turned itself into a weight of lead that could not be dislodged.

Sometimes, however, his stomach did go so far in its rebellion as to force up everything he had swallowed. Various lessons of this sort at different times taught the boy one of the great lessons of his life — that he must keep calm and serene at meal time.

At this moment I think of two different families in separate towns, wide apart. Four children, two parents, a dog, and a cat make up each family. Each also seems

[1] The account of these experiments is given quite fully in *The Body at Work*.

to have its own distinct family motto: "Good Cheer!" for one; "Discontent," for the other. And meal time is the grand parade ground for these mottoes.

In the Good-Cheer family cross looks and unkind words are positively forbidden, while teasing is voted down by unanimous consent. Meal times here are joyful occasions which provide good cheer and courage for all. If indigestion ever attacks a stomach in this family it will have to travel by some other road than that of the uncomfortable mind and the sympathetic ganglia.

In the family of "Discontent" the law of practice seems to be: "Tease, quarrel, complain. Get as much as you can. Give as little as you must. Be discourteous and unamiable whenever you feel like it." And the law bears fruit at meal time and between meals. Parents and children alike act as if they had never dreamed of any connection between good health and good cheer. For this or some other reason both parents have nervous dyspepsia already. And, at the present rate of progress, it looks as if the children might reach the same goal at an early age.

These are not imaginary families. I know both sets of children and all four parents. I have held the cats in my lap and petted the dogs.

Scientists find four good reasons why happiness helps the body.

1. A happy state of mind affects the ganglia in such a way that they compel the small blood vessels to expand. This allows fresh blood to flow easily through them.

2. A happy state of mind affects the nerves that control the lungs. They inhale more air. This means that they get more oxygen, too; and this, in turn, means that the blood is better purified by the lungs.

3. A happy state of mind affects the ganglia that control the heart, making it beat faster; this forces fresh blood rapidly through the expanded blood vessels. And rapidly moving blood gives rich nourishment to neuron and muscle, making it possible for them to do good, energetic work.

4. A happy state of mind affects the ganglia of the stomach so promptly that its churning is better done; while, at the same time, more gastric juice pours in to help digestion along.

A cheerful schoolroom, lively games, pleasant friends, becoming clothes, travel by steam and by rail — anything that makes us happy without doing us harm is a help to the body through the sympathetic ganglia.

We now see why it is that we learn our lessons faster, recite them better, and are quicker-witted in every direction when we are joyful than when we are joyless and hopeless. It is simply because in the former state every

organ in the body is doing its best work, and because the brain gets the benefit of it all through an improved blood supply. The serious fact is that the human machine is so delicately balanced that when even the smallest part of it fails, the whole may hitch and halt. Wear out the fire box or the boiler of an engine, and no matter how perfect the rest of the machine may be, it will run no better than a worn-out affair that is rusted in every joint.

It matters not where the hitch in the human machine begins—whether with too much food, too little mastication, too little exercise, too much worry, excitement, anger, fear or torment of any mental sort; for, wherever the start may be, the feelings are sure to be pulled into the reckoning ere long, and after that the trouble is increased tenfold.

It is evident, then, that we have within our own reach methods for securing good service from our sympathetic ganglia:

1. By avoiding, as if it were a poison, each thought and emotion that saps the vigor of the ganglia: hatred, malice, envy, jealousy, anger, despair, discouragement, anxiety, worry, fear.

2. By helping the ganglia through love, joy, hope, courage, faith, trust, belief in others, belief in ourselves, good cheer.

3. By obeying all the health laws that we know anything about.

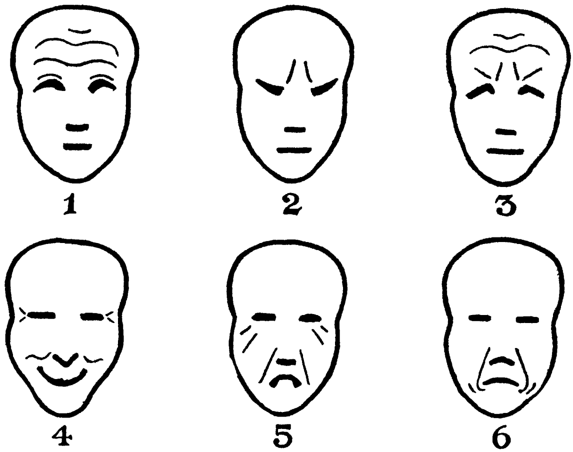
In talking this over the other day, my friend said: "But if I feel cross, can I help the feeling? If I am worried, can I help being worried? If I am sad, can I compel myself to be happy?" In other words, she wished to know whether or not there is any way by which a human being can turn off the current of such feelings as will harm the power of the neurons, and turn on the current of such other feelings as will help the neurons to help the body.

Certain wise men are very sure that they have discovered the way to do it. They suggest a simple device. Test it for yourself. When you get up cross some morning, notice your actions. You will see that you are very much inclined to speak sharp words, to slam doors, to tease the cat, to think evil of others, to believe that others think evil of you.

Now, in the midst of this miserable state of affairs, you are to make a firm resolve to do opposite things from those you seem to wish to do.

To start with, however, look at your face in the mirror. Notice its expression, if you can catch it before it vanishes, and promptly change it for one that shows good will and brave determination. Hold on to this expression throughout the day. Don't let it leave you for a moment. It will be as a tonic to your neurons; it will end in making you as cheerful as you look, and this will help others no less than yourself.

For the same reason, let every act carry out what your face declares. When you feel like saying cross words, be sure to have wit enough to say pleasant ones instead. When you feel like slamming the door, or like breaking your shoe string with a jerk because it has a knot in it, shut the door gently and hum some cheerful tune while you carefully untie the knot in the string. Sing when you wish to scold; smile when you wish to frown; do some kindness when you feel like being unkind; praise the one whom you wish to blame, and continue in these directions for three consecutive hours, even longer if necessary.



MUSCLES MAKING REVELATIONS
1, astonishment; 2, reflection; 3, pain; 4, laughter; 5, weeping; 6, contempt. — After Schmidt

If you follow out this plan faithfully, when bedtime arrives you will find that you have done a surprising piece of business. You have wrung victory out of what might have been a day of dismal defeat. You have been strong enough to influence your neurons by your actions.

By your own experiment you have learned how to govern the ganglia through the laws of modern science.

Indeed, you have succeeded so well that heart and stomach, blood vessels and brain, each in its own way, has done a good day's work.

I must, of course, confess that no weak person ever succeeds in this endeavor. It takes a firm will and a strong character to do it. But the person who really is strong enough to turn his sympathetic ganglia into life preservers for his service, proves that he is master of a superior set of neurons. And the man who has force enough to master his own neurons is sure to become a leader of those with whom he comes in contact.

It is important to know that this scheme of acting in a certain way for the sake of capturing a happy state of mind is a very different matter from that of being hypocritical for the sake of trying to seem to be what we are not. In the former case we are doing what we can to improve from inside outward; in the latter case we are simply trying to hide inside conditions which we are perfectly willing to cherish but which we are ashamed to acknowledge.

The hypocrite is the most despised of men; but, on every hand, he who battles with himself is looked upon as a hero.

CHAPTER XX

SELF-CONTROL AND CIGARETTES

The mere fact that a boy rises in great excitement at four o'clock in the morning and goes off fishing does not prove that he really likes to get up early. Indeed, it proves nothing more than that he enjoys fishing so well that he is willing to vote against sleeping for that particular morning. When fishing is out of the question, his bed and his sleep may be as tempting as ever.

We might imagine a case somewhat like the following. Two hunters go off together. Each has the same amount of powder and the same kind of gun. Each needs to secure as much game as possible for his family. Both are good marksmen, and they enjoy shooting even when it is merely for the fun of hitting things at the risk of wasting powder. But one of the men refuses to do this. He claims that he will need all his powder for his big game later. The other shoots at twigs and leaves and any flying target. "It's great sport," he says. "I believe in getting some fun as you go along." "I believe in having a great deal more fun later on," replies the other.

When the day is over the tables are seen to be completely turned. One man returns with even more game than he had hoped to get; the other finds that, by using up his powder on small things, he has robbed himself of big game.

FOUR O'CLOCK IN THE MORNING
He leaves his bed for the greater pleasure

The man who wastes his powder, his time, his money, or his strength; the boy who wastes pennies or opportunities; the girl who shirks home duties or neglects her lessons; the woman who gossips or idles her days away; all these and a thousand others are taking what they consider pleasure as they pass through life. They are using up their powder on small things with no eye for big game in the future.

Multitudes of people do, however, work according to an opposite scheme. They have learned from experience that he who can deny himself a lesser present satisfaction for the sake of that which is greater —

although it may be further off — will come home richer from the hunting ground.

This is true in every department of life, and it applies particularly to certain habits of indulgence which we may allow ourselves to form; for, by these habits, we may rob ourselves of power to do anything well.

The following cable report illustrates my point. It reached Chicago from South Africa and London in 1904.

> The cigarette is playing havoc with the British army. One of the officers who has had to do directly with the boys as they arrive is simply in despair. He says it will take three years of feeding and training to bring them up to a point where they will be capable of doing a day's work without breaking down. The chief disposition of most of the recruits seems to be to hunt some place to lie down for a rest. Where, in former days, they ran the sentries and raised all sorts of trouble, they now dodge the noncommissioned officers and go to sleep. The whole trouble is traced directly back to cigarettes.

The United States meets the same sort of situation. In Peoria, Illinois, four hundred and twelve boys were examined by a naval officer, and only fourteen were accepted. Most of the others were rejected because of weak hearts, and in almost every case the weakness was due to cigarette smoking.

These facts are so entirely in line with those given in the eighteenth chapter of *Town and City*, that we understand why General Wingate was so much in earnest when he gave advice to the Public Schools Athletic

League of New York City. His advice was addressed to an army of thirty thousand public-school boys, for that was the number of those who competed for prizes there in 1906.

"Above all," he said, "*You must not smoke cigarettes.* It stunts your development, injures your heart, and spoils your wind."

For the same reason, every good athletic coach or trainer forbids tobacco to his men. They all know that, whatever else a competitor does, he cannot afford to weaken the power of his heart.

To go into the matter a little more precisely — what are some of the most noticeable marks and signs, badges and blights, of the cigarette smoker? The following list was made out by an inspecting surgeon at military headquarters in South Africa. He had no difficulty in gathering his facts, for hundreds of cases were before him — hundreds of young Englishmen who had gone to South Africa as recruits for the British army.

Marks of the cigarette smoker who has damaged his body: chronic hoarseness, lack of appetite, dyspepsia, pallor from impaired blood, rapid and intermittent pulse, pain in the region of the heart, difficulty in breathing, disinclination for healthy, athletic exercise, headache, mental weariness, slowness of thought causing muddled ideas, defective memory, impatience, irritability. No smoker endures within himself all these woes at the same time. Some

of them, however, he is likely to have; for boys in every land suffer the same misfortunes from the same causes.

Judge Stubbs of Indianapolis brings a terrible charge against the cigarette. He says that every year boys by the hundred are brought to him for judgment, and that "manliness and good conduct can be aroused and stimulated in most boys, no matter what the offense of which they have been guilty, if only they are not cigarette fiends." Then he adds:

> When a boy has become addicted to the use of cigarettes the disease is in his blood and brain; his moral fiber is gone; he is apathetic, listless, and indifferent in school; he fails to hold a job of work if he is put to work, for the reason that he hasn't sufficient strength to do the work that a boy of his age ought to do easily; his vitality has been sapped, and all the vigor that characterizes the normal boy is gone. The probation officer has but small chance to reform and help a cigarette fiend unless the habit can be broken. It is a fight with the boy's appetite which, like the burning thirst of the inebriate, rarely listens to moral suasion. When a boy is in this condition he is easily led into offenses against the law. We have found that when a boy is guilty of a grievous offense he is generally found to be a user of cigarettes.

Testimony might be heaped up mountain high, but enough has been said to prove the charge.

We wonder, perhaps, how so pretty and attractive a thing as a cigarette can do such harm, and why the present pleasure of smoking cannot be a permanent pleasure too.

The mischief lies, of course, with the poison which is part of every tobacco leaf. A drop of it on a dog's tongue kills him instantly. When the leaves are heated, as in smoking, the poison is turned to gas; and it is just here that the harm of the cigarette shows itself, for the poisonous gas is intermingled with the smoke. Both are drawn deep into the tubes of the lungs, and there they come in contact with one of the most sensitive membranes of the body.

The lining of every finest branch and twig of the lung tubes is, indeed, made for nothing else than to absorb gas. To them it is that red blood corpuscles go for that oxygen which is needed for the life of both muscle and neuron. He who draws tobacco smoke into his lungs not only robs his red blood corpuscles of the oxygen which they have come for and which they must have if the body is to be put into good condition, but cigarette smokers cover the delicate tissues of the lungs with flood after flood of smoke, in which is mixed a harmful poison.

It also appears that this poison is particularly bad for the neurons of heart, throat, ear, and liver; and that, although one cigarette carries very little of it, still cigarette added to cigarette supplies the body with enough poison and robs it of enough oxygen to explain all the havoc that follows.

Especially does the heart suffer. Its power to pump is weakened. "It is easy thus to understand," says Sir

Lander Brunton, "how a man using tobacco to excess may at the same time have 'smoker's sore throat,' 'tobacco heart,' and 'symptoms of indigestion.'"

In using cigarettes, he who smokes one is so sure to end with the habit of smoking many, that scores of business men are making a stand for total abstinence in this direction. They know that in these days of keen competition it is only the clearest head and the shrewdest wits of a vigorous brain that will win in the race for success of any kind; and they are not willing to risk their business in the hands of those who are dulling their brains through tobacco smoke and the poison of nicotine.

Mr. E. H. Harriman, head of the Union Pacific Railroad system, says that officials "might as well go to a lunatic asylum for their employees as to hire cigarette smokers."

In St. Louis the superintendent of the Lindell Street Railways says:

> Under no circumstances will I hire a man who smokes cigarettes; he is as dangerous on the front of a motor as a man who drinks. In fact, he is more dangerous; his nerves are apt to give way at any moment. If I find a car running badly, I immediately begin to investigate, to find if a man smokes cigarettes. Nine times out of ten he does, and then he goes, for good.

I quote a few other opinions from among multitudes of protests.

In John Wanamaker's stores the application blank to be filled out by boys applying for a position reads: "Do you use tobacco or cigarettes?" A negative answer is expected, and is favorable to the applicants.

Ayer's Sarsaparilla Company, Lowell, where hundreds of boys are employed, has issued the following:

> March 1, 1902. Believing that the smoking of cigarettes is injurious to both mind and body, thereby unfitting young men for their best work; therefore, after this date, we will not employ any young man under twenty-one years of age who smokes cigarettes.

Chief of the United States Weather Bureau, Willis M. Moore, has placed the ban on cigarettes in this department of government service.

The assistant general manager of the Cumberland Telephone and Telegraph Company has issued the following order: "You are directed to serve notice that the use of cigarettes after August 1 will be prohibited; and you are further instructed, in the future, to refuse to employ any one who is addicted to the habit."

The Pittsburg and Western Railroad forbids the use of cigarettes by the attaches of passenger trains, and notifies travelers that they must not smoke cigarettes in the passenger coaches of the company. I have also been told that on the Superior and Wisconsin Railroad twenty-five laborers, working on a bridge, were discharged by the road master because they were smoking cigarettes.

And now comes the moral. Since so many human beings do use tobacco every day, we are forced to conclude that smoking gives a real pleasure for the moment. We also conclude that those who do the smoking belong either to the one or to the other of the following two classes:

1. These are thoroughly sensible people, but they have never heard of the effect of nicotine on the neurons; and they do not know that when they send smoke into their lungs they rob their blood of the oxygen it needs. If they knew these facts, they would not smoke.

2. These are not ignorant. They know the facts, but they enjoy smoking to such an extent that they are willing to risk in exchange for it health of body, vigor of brain, and such success in life as added vigor of brain and body might bring to them. Such people are the hunters who are willing to use up their powder for fun before they reach the hunting ground.

CHAPTER XXI

WE TRAIN OUR SENSES

Jemmy Morgan was blind from the time he was born until he was three years old.

His father was a farmer who lived near Bristol, England; and that meant that there would have been every sort of delightful out-of-door life for the boy if he had had the eyesight for it. At last, however, he received it as a gift. A skilled surgeon performed the operation.

When it was successfully over, and Jemmy looked at the world for the first time in his life, the query was as to whether or not he would be able to see intelligently from the start; that is, whether or not he would be able to understand what he saw without being trained for it.

The question was answered very promptly, for when the boy's friends put things in front of him and asked him to take hold of them, he acted as a baby does when it is trying to clutch its toes. In other words, he groped round rather awkwardly before he could so much as touch the article he wished to hold. Naturally, of course, he was quite as awkward whenever he tried to help his walking by watching his footsteps. In fact, he seemed

to find sight so confusing that his relatives often saw the little chap shut his eyes when he really wanted to hurry from one part of the farm to another.

Within a few months, however, his eyesight was as well trained and as useful as is that of any other three-year-old boy.

This case made it quite clear that a child of three needs to train his eyesight to make it useful to him. But what about an older person? Does he manage better?

Dr. Carpenter tells about another boy who was blind until he was twelve years old. Then came the operation and the eyesight. After that there were various amusing times both for the boy himself and for those who watched him. He had already learned to recognize animals, people, and things by the sense of touch alone. And now, when his eyes looked about for information, they recognized nothing which they saw. Cats and dogs, wheelbarrows and chickens, people and pumpkins, were in plain sight, but he could not mention the name of one of them until after he had felt of it. His old, well-trained sense of touch had to supply his new sense of sight with information.

One day the boy was seen to gaze steadily at his cat for some time. He was trying to decide by sight alone what the creature was. But he came to no conclusion. Then he picked her up, looked at her intently as he

felt of her all over carefully; and, as he set her down, some one heard him say, "So, puss, I shall know you another time." Touch had given sight a lesson on cats. This sort of teaching went on every day until the boy's eyes were able to gather information for themselves.

Yet touch itself also learns all its lessons through training and experience.

I know a baby who once seized a smoking hot potato and continued to hold it in his small fist while he screamed with pain. He did not know enough to let go. He did not know where the pain came from. His sense of touch had never before had any training.

Laura Bridgman is the great example of what one may learn through the sense of touch alone. Nevertheless, when she was born in Hanover, New Hampshire, in 1829, she was as well off as any other baby, and every sense remained perfect for two years. Then, however, came scarlet fever, and when she recovered she could neither see nor hear, taste nor smell.

It is true that, for a while, her right eye helped her to get the outline of large things in bright places. Still that was all; and after her eighth birthday even this power slipped away. From that time forward Laura lived in total darkness—in total silence too, for, from the time of her illness onward, even a crash of thunder brought no more sound to her than the gentlest whisper. Her world was as quiet and dark every day as if she were

living in a fathomless well. Moreover, as she had never heard a human voice say a word, she herself did not learn to speak.

Her sense of touch was left, however. She could feel things. She learned through the tips of her fingers. First came the names of different pieces of furniture. Her teachers pasted these in raised letters on the things they represented. Laura then felt of each name and learned to recognize it on the instant.

LAURA BRIDGMAN
Touch was her only road out to the world

When she found herself quite able to separate all the words into letters, and put them together again, and spell the names of different articles for herself, she could hardly contain her joy. Her thinking neurons had found occupation at last, and she became so enthusiastic that her teachers had to hold her back from her studies. She was ready to go without sleep at any

time for the sake of study. She had learned how to widen her one solitary road out to the world, and she was bent on making it wide as fast as possible.

Not only did she do this through reading, but she did it through writing, too. She also learned to talk by spelling words out with her fingers as deaf people do; and she understood what others said to her by feeling of their fingers as they talked to her through the same silent language.

She recognized her friends by their hand grasp or by gently touching their faces with the tips of her fingers. She enjoyed the companionship of others, kept herself neat and tidy, was orderly in her room, and liked to be well dressed. Indeed, she learned one thing after another so fast, and was almost always such a happy child, that it was hard for others to realize that she lived in a world that was always quiet, always dark, and that her only connection with that world was by the road of touch.

Day by day she continued to widen this road, however, and the fascinating occupation was kept up until she died at the age of sixty-two. She had lived a courageous, cheerful life, and had taught the world what pluck and persistence will do through the sense of touch alone.

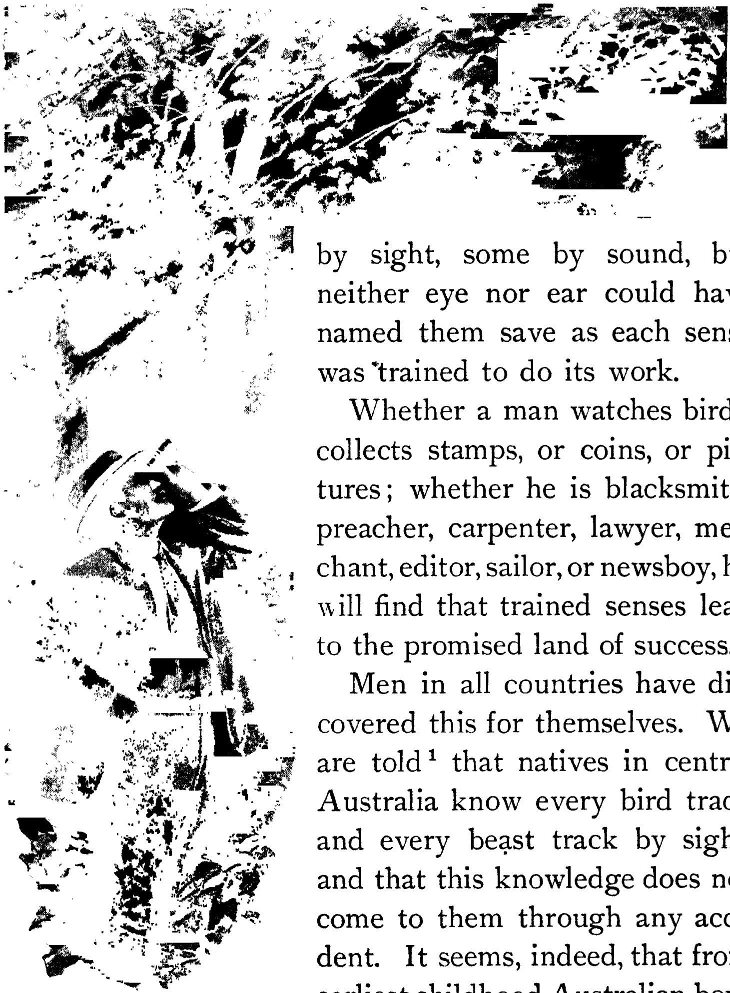
The history of what this one woman accomplished with her one sense points the way to what each of us may accomplish with our five senses, provided we are willing to take the trouble to give them careful training.

A friend of mine whose senses are all in good working order is developing two of them in a delightful way. He thinks he is simply studying birds. This indeed he does. But while he studies his birds his eyesight grows keener in its power to recognize them, while hearing also grows more trustworthy, and the outcome of it is that almost never does a bird fly overhead within sight or sound of him but he recognizes it at once.

Sometimes he knows it by the way it flies; sometimes by the color of wing, breast, or tail; sometimes by its shape; sometimes by its size. Whatever the mark, in a flash, when he sees the bird, he knows it and names it. Others who are with him may have seen nothing but a bit of color passing by, or a small shape on a swaying tree top; but he has seen all that the trained eye can see, and he is able to give the color or the shape its own definite name.

What he does not see he often hears. He sits under a wide tree, and with every bird song that reaches him, every twitter, every call or cry, he names the bird. He will also tell you whether it is singing to its mate on the nest, whether it is talking to its young, or giving a warning cry that danger is near.

This college student keeps a record by name of all the birds he sees or hears. It is now early June, and already, since January, his roll call includes one hundred and seventy-three different birds. Some he has recognized



WITH TRAINED EYESIGHT HE STUDIES THE BIRDS

by sight, some by sound, but neither eye nor ear could have named them save as each sense was trained to do its work.

Whether a man watches birds, collects stamps, or coins, or pictures; whether he is blacksmith, preacher, carpenter, lawyer, merchant, editor, sailor, or newsboy, he will find that trained senses lead to the promised land of success.

Men in all countries have discovered this for themselves. We are told[1] that natives in central Australia know every bird track and every beast track by sight, and that this knowledge does not come to them through any accident. It seems, indeed, that from earliest childhood Australian boys

[1] Related by Baldwin Spencer and F C Gillen.

and girls are taught to notice tracks of all sorts, and that at the same time they are also taught to imitate these tracks with their fingers in the sand.

The result is that a full-grown experienced tracker, as he is called, can follow obscure tracks which we should never notice, and can recognize them even as he rides past rather swiftly on the back of a horse.

But eyesight and touch do not stand alone; the power to smell may be trained too. Think of the Indians in Peru. Dr. Carpenter says that in the darkest night these people can tell, by the smell which reaches them, whether a stranger who approaches is an Indian, a European, or a negro. For them, as for the others, it is a trained sense that does the work.

We see, then, that the same law is true for all sorts of people in lands however far apart. Everywhere he who wishes the keenest and the surest sense of sight or sound, taste or smell or touch, may secure it by close attention and constant practice.

The encouragement is, that by giving ourselves training enough we shall secure the thing we desire.

CHAPTER XXII

FIVE SETS OF NERVE ENDINGS

If the statue of Liberty at the entrance to New York harbor had a healthy set of neurons supplying her five senses; if these neurons were rich in axons and dendrites from foot to brain; and if, by some accident of shot or shell the foot of that towering goddess should be shattered some day, she might see the thing happen on the instant, but she would feel no touch of pain for a full second afterwards. It would take that much time for the stimulus to travel from foot to head, because the two places are one hundred and eleven feet apart.

Scientists prove this rate of travel by experiments with animals and human beings. They have invented various instruments of different size and shape, each one of which is supplied with a device for keeping records. And through these instruments the fact is made plain that a stimulus from the skin travels to the brain at the rate of from ninety-eight to one hundred and thirty-one feet a second. It goes faster or slower according to the number of transfers that have to be made from neuron to neuron in the relay race upward.

It is through such experiments then that we know where it is that we actually suffer.

A child may say: "My finger hurts. I burned it." A man may say, "I am suffering frightful pain in this gashed foot of mine," and, if we are ignorant enough, we may believe them both. But a scientist knows better. He assures us that there is no pain whatever in the injured part itself; that every sensation we have, every pain we feel, is simply a proof that a stimulus of some sort has reached the brain from this place or that. He says that, as soon as the stimulus arrives, the brain cells which receive it are changed a little by it, thus occasioning what we call sensation. This stimulus may travel from eye or ear or any other starting point.

THE STATUE OF LIBERTY

It is by means of my brain, then, and through the neurons which make up the gray cortex of the cerebrum, that I not only think but feel. Thus too I see and hear, taste and smell. For, as the last chapter showed, it is by the five great nerve roads that lead to the brain from eye and ear, from nose, tongue, and skin, that we learn what is going on in the world outside of us.

Our own experience shows us that each sense may serve us separately, or that all may serve us together, thus giving us various sets of side views of the same thing.

At this moment I think of some chocolate creams which I ate last evening; and it takes several senses, working together, to tell me what they were like. Neurons of sight tell me they were small, brown, and almost round. Neurons of touch tell me they were smooth and rather soft. Neurons of taste tell me they were sweet and delicately flavored. And it is the combination of information from these three sets of neurons that gives me my true idea of chocolate creams.

Carry the same notion out in other directions. See for yourself how, throughout an entire day, each sense pieces out the others. Everywhere you will find that the more senses you can bring to bear on any object, the more perfectly will you understand and remember it. So true is this that our thoughts about anything are richer or poorer according as different senses have been allowed to bear on the same subject.

When Laura Bridgman thought of a rose, what did the flower mean to her? Touch reported a cluster of delicate, smooth petals, supported on a round stem that sometimes carried points that pricked her unawares.

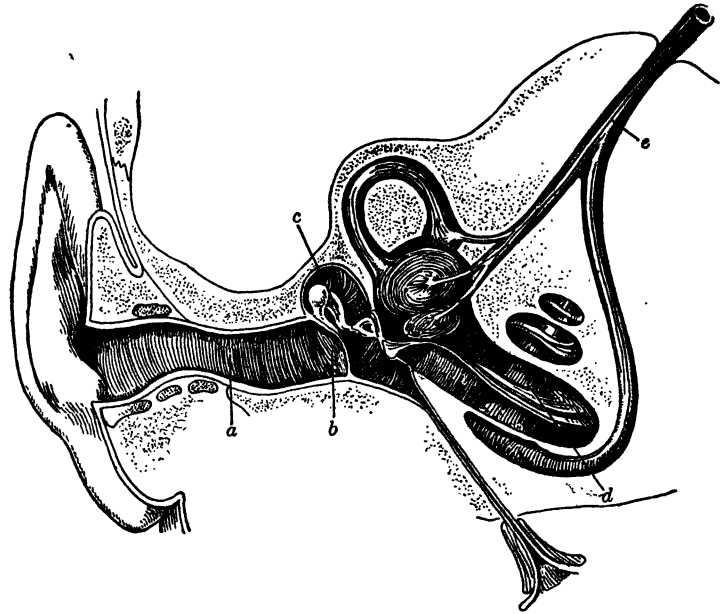
But let sight and smell add their reports and give us the rose that we ourselves have in mind. Color is added now, and we see the shadings of the petals, the wonderful tracery, the shadows between them, the green calix, and the sunshine over the whole. And added to all is the fragrance — a wave of odor so rare that whenever we see this shade of pink elsewhere our thoughts fly swiftly to the fragrance of the rose.

A flower that reported neither color nor fragrance would not enrich the mind very much.

Always, then, it is the combination of the work of the senses that makes the most complete and lasting impression. And it is fortunate for us that our senses do not need to wait for each other in the work they do for us. At the moment when I see I may also hear, and while I see and hear I may also taste and smell.

Many public lecturers have this fact in mind when they are particularly anxious to hold the attention of their audience. Such a man talked in this town not long ago. His subject was the land of Palestine, and as he talked he used his stereopticon, throwing one beautiful scene after another on the screen. He was compelling our neurons of sight to help our neurons of sound

in understanding his descriptions of the places. The scheme worked well. We not only understood him better as he talked, but the impression made will last longer, for two sets of neurons have it in charge.



A PIECE OF APPARATUS THAT HELPS HEARING

a, the tube; *b*, the eardrum; *c*, the ear bones; *d*, the snail shell; *e*, the nerve of hearing

Good teachers work on the same principle. They use blackboard and illustration cards whenever they can. In teaching others, or in trying to understand and remember on our own behalf, let us not forget that the larger the number of neurons we can force into our

service the clearer will the impression be; and that the clearer the impression is, the longer will it stay by us.

Along with all these facts it is important to remember that each separate sense depends on the work done by three parts of a delicate piece of machinery:

1. Apparatus which receives stimulus — eye, ear, nose, skin, etc.
2. Axons which carry the impulse.
3. Cell bodies in the cortex which recognize the impulse when it arrives.

In the case of each sense, also, we must suppose that the outside apparatus itself knows no more about what is happening to it than the mouthpiece of a telephone knows what we say when we speak into it. In point of fact, the receiving apparatus of each sense is nothing more than a marvelous device for receiving its own special kind of stimulus. Ear apparatus receives a stimulus, and when that stimulus reaches the brain by way of ear axons, we say we have heard something. Eye apparatus receives a stimulus, and when that stimulus has reached the brain on eye axons, we say we have seen something.

Skin and nose and tongue serve us in the same way. Each is a piece of apparatus that receives stimulus of its own kind and sends it up to the brain on its own distinct set of axons. In every case the brain is the receiving point, and the cells are the basis of our sensations.

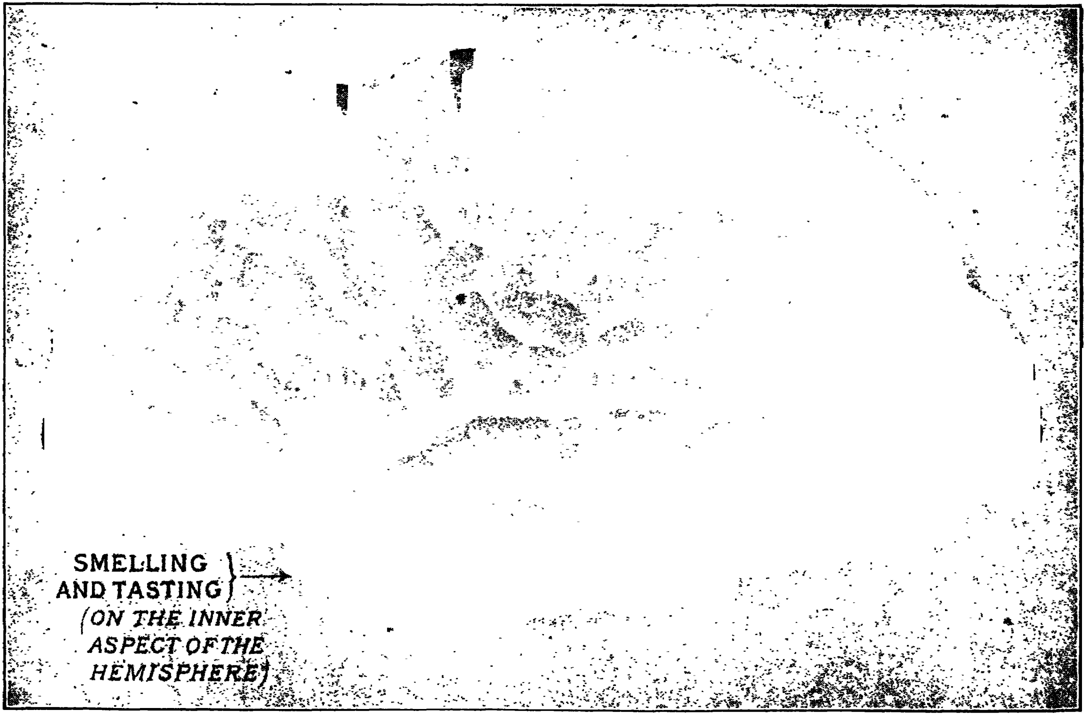
Since we know these many and various facts; and since we also know that exercise always develops any part of the body that is used vigorously, we are not surprised to hear that, by examining a brain after death, a trained scientist can tell just which set of neurons did the most work during life.

These men may, for example, take a bird that has lost its life, and point to a certain place on the brain. "You see it is very much enlarged," they say. "That is the part that always had the most exercise. It is the sight center of the cortex." And at once we call to mind the stories we have heard about the carrier pigeons and other birds — about the keenness of their vision and the distance they can fly from home.

The brain of a dog may be examined next. "There!" the scientist exclaims; "do you see this part? It is the center for smell, and it is always greatly enlarged in dogs." And now we recall all our dog stories. We remember that a bloodhound will trace a man through a crowded city; that the scent of a dog is one of his most remarkable points.

The examination might go on from brain to brain, from animal to animal, each showing that one of the senses was more highly developed than any of the others.

In the human brain, however, affairs are generally better balanced. Each sense has been active, and all



THE LEFT HALF OF THE HUMAN CEREBRUM

The words "leg," "trunk," "arm," "face," are printed over the centers that control the corresponding parts of the body. Other words show where different sensations and memories are located

are fairly well developed. But perhaps we wonder what happens in a case like that of Laura Bridgman. Did her brain betray anything about its lacking senses?

Doctors not only asked precisely this question, but they answered it. They could do this because they were granted the privilege of examining Laura Bridgman's brain after she died. The result of the examination was that they found the cortex thinnest at the centers for seeing, hearing, tasting, and smelling.

Not only this, but they also saw that the part which belonged to the left eye — the eye that saw nothing from the time Laura was two years old — was much thinner than the part which belonged to the right eye. As we know, this right eye had served her a little until she was eight years old.

As might have been expected, the touch region of Laura's brain was found to be wonderfully developed.

In view of these facts, we draw the following conclusions for immediate use.

1. Although the outside apparatus does nothing but receive stimulus of one sort or another, still, if it is ruined by disease, accident, or careless use, no amount of striving on our part will restore it to us. (Look up *Good Health* on the care of eye and ear.)

2. If the apparatus of one sense has been wrecked, the other senses may be so highly developed as to help make up the loss.

3. Persistent exercise of any sense will increase the thickness of the part of the cortex to which it belongs.

Although no examination of the cortex of our own cerebrum is possible while we are alive, still we may have the comfort of knowing that we are improving its quality here or there in proportion as we are giving one sense or another more or less exercise. The truth is that our senses are our best friends or our worst enemies in just such measure as we train or neglect them.

CHAPTER XXIII

WHY INCREASE THE DENDRITES

After chick and lizard, amphioxus and bird are hatched; after kittens, puppies, and babies are safely born, each continues to grow precisely as it did while it was being developed. That is, every addition to the body of any living creature of any size, from microbe to elephant or whale, is always made by the dividing and the multiplying of individual cells.

This is true of bone and muscle and tendon in every part of the body save one; and the lack in this one direction makes us catch our breath with surprise and even with alarm.

Scientists tell us that practically all the nerve cells — the neurons — that a human being is ever to have, are lodged within him when he is born; and that, although a man may live for a hundred years or longer, and although he may strive throughout each one of these years, the number of his neurons will remain forever the same. Each grows larger, to be sure; axons stretch away from them, long and slender; dendrites may increase; but no amount of wishing or striving or eating or

sleeping will ever give any human being more neurons than he has in the beginning.

This fact makes the outlook rather dismal for those of us who wish to improve our minds; and we turn abruptly to scientists with the question, What then can we do to increase our wisdom and our skill? The answer comes back without a moment's hesitation: Increase your dendrites and connect the neurons.

Further questions bring out further answers, and we end by knowing the following surprising facts.

1. The difference between the power of one brain and another may be nothing more than a difference in the way the neurons are connected with each other.

2. Brain messages run constantly back and forth between different parts of the brain to keep our thoughts from getting disconnected and to keep the messages to our muscles from being confused.

3. These messages must travel from cell to cell, along paths that lie in the dendrites and the axons.

4. To increase intelligence or dexterity in any given direction, increase the number of the paths that connect the neurons which you must use.

Brain paths, then, are our only hope — paths within those dendrites and those axons which clasp hands with each other and bind the neurons together. Our task is clear and simple. We must make as many connections

as possible between any set of neurons that govern the special line of thinking or working in which we wish to excel.

But how can we hope to change the number or the power of those slim, twisted fibers that control our destiny? The answer to this question opens a door of hope for each of us.

Persistent practice in any direction develops paths between the neurons which control that particular line of thought or exercise. It is indeed supposed that this practice increases the number of the dendrites themselves.

When you see a boy who is awkward in running and jumping, and a girl who is clumsy in sewing, or cooking, or playing the piano, you have the right to say, "Evidently they are doing the best they can at the present moment, but they have not practiced enough in the past to develop the dendrites that will help them now."

On the other hand, if you see men or women do this thing or that easily, you may say: "I feel like praising them, not for what they are doing now, but for what they have already done; for the faithful practice which has given them this superb system of paths between millions of cells — paths which make it possible for them to do this difficult thing at the present time."

A cousin of mine had been trying all the evening to play hymn tunes on the piano, but she did not succeed very well and could not understand why she failed. "I

see the notes distinctly," she said, "and I know perfectly where my fingers ought to go; why, then, do I have to fumble so? Why can't I hit the keys?" And I exclaimed: "Don't blame your present self. You are doing the best you can just now. Blame your past self that didn't practice enough to develop the dendrites with their paths."

There is no question about it. Connections are increased through diligent practice in definite directions.

One man will play the violin easily and brilliantly. Another man, with quite as good a mind and quite as kind a heart, will say: "Thank you, I'd like to do it since you wish me to, but you see my fingers are too stiff. I've hardly ever done any violin practicing. My work has all been on the organ." We therefore blame the man no more for not being able to play the violin than we should blame a baby for not being able to ride a bicycle. We know that the needed neuron connections are lacking for both of them.

Just here it is well to know that even as the bones and muscles of a child grow faster than those of older people, so it is also with the dendrites and the paths in them. Prove this for yourself. Notice how quickly a child learns to ride the bicycle or to dance, to talk a foreign language or to play games. Then notice what slow work an old man makes of these same things. It is for this reason that parents and teachers should give children's neurons a chance while the children are

growing. Connections between different sets of neurons, in any direction whatever, develop fast while a child is young. And those that develop then are capable of doing such good work that they will save him years of time and toil later. For, in those later years, dendrites and paths are slow of growth, and, in certain directions, they do not seem to do as good work even after they are grown.

This is precisely why you "cannot teach old dogs new tricks." It is simply that the dog is old and that it is hard for him to make paths between the neurons. Those which were made in youth, whatever their character, must serve both dog and man in old age. Indeed, it is as true for a puppy and for a child as for a farmer, that any harvest in the summer and fall of life will be measured by the work that was done in the spring.

Clearly enough, there is no such thing as luck in this law of the dendrites. And, quite as clearly, just because luck is cut out, the road to success is open to each one of us. When we are trying hard to learn anything, let our watchword be, "May my dendrites grow; may my brain paths increase." Any boy who follows this inspiration may turn himself into the man he wishes to be. Any girl may become her own model. Neither dares to trust to luck, for both know that, from the time the first stimulus went across the first amœba until now, no accident has ever built up a fine set of brain paths.

No baseball team allows its pitcher or its catcher to be a man who trusts to luck. Instead, these men must be such as have developed the needed brain paths until they are able either to pitch a good "out curve" or to catch a ball "on the fly."

As in ball playing, so in every other direction it is the men and women with countless well-trained servants in the shape of dendrites that are the leaders of the world to-day. The best writer, the best orator, the best scientist, lawyer, preacher, and musician, each one of these owes his high station to the splendid sets of dendrites that put multitudes of neurons in connection with each other and increase the power of each.

No doubt some people start life with more neurons than their neighbors have ever dreamed of having, for the quality of the brain we are born with is due to our ancestors. Through them we may begin life with the brain of a poet, of an inventor, of a musician. We may be gifted in one way or another before we leave the cradle, or are old enough to do any thinking; and for this we deserve neither praise nor blame.

Clearly enough, however, there is no way to count nerve cells, no way to tell whether the brain of one baby is better than that of another except by what the baby proves himself to be when he is old enough to show what his own particular brain can do. We have no choice but to judge a brain by what it actually does.

For this reason, any child who begins life with fewer neurons and a less gifted brain may, after all, win in the race against the other child who had more neurons to start with, but who took no pains to develop brain paths.

There is, in fact, no way to count brain cells — no way to compare one brain with another except by what the person proves himself to be. I myself should prefer to own fewer neurons joined to each other by multitudes of dendrites, than to own more neurons, if they had to be of the sort that lacks energy enough to make connections with other neurons.

Many a child gives up a hard undertaking simply because he does not know about this law of neuron connections. A young friend of mine was threatened with blindness. Everything had to be done to save her eyesight. Her parents even went so far as to send to the blind asylum in Columbus, Ohio, for pages of raised letters. They thought that, as she was a great reader, she might learn to save her eyes through the tips of her fingers.

She began with enthusiasm and kept at it for two days, when she gave up in despair. "My fingers are too stupid," she said; "they can never learn all that." Unfortunately, those who were with her did not know about neurons, or they would have explained that there is no such thing as making brain paths in a trice — that time and patience are necessary. If she had known this at the

time, she might have kept on pluckily for a season and have ended with a new set of servants at her command.

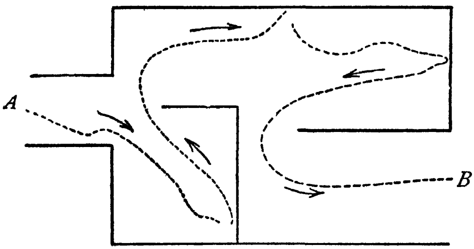
In a way, it is these different neuron connections which we ourselves have made that tell tales about us on every side. Keep your eyes open and learn to decide what sets of connections have been made by the different people whom you meet. As a rule you will be able to tell whether these connections were started in childhood or in later life; for the things which each man does most easily are apt to be those which travel over paths that were developed in childhood. One of the most important questions about every school child is, How much is he willing to do for the sake of connecting his neurons? Let us all bear the following law in mind: The connections which we consent to make, or which we choose to make, as children, will rule us with an iron hand, for good or ill, when we are old.

In view of this law it is evident that what we wish to be when we are old we must begin to be while we are young.

CHAPTER XXIV

IN ORDER TO REMEMBER

Two scientists proposed to study the memory of a crab, for they wished to know whether or not such animals have intelligence enough to make use of their own experiences. For the sake of the test, these men constructed a confusing path through which the hard-shelled, small-eyed creature must go to find his food.

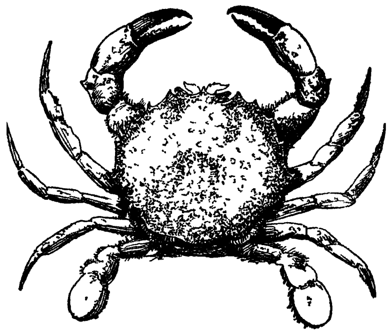


THE ROAD THE CRAB TOOK BEFORE HE LEARNED THE SHORTEST WAY THROUGH

The crab was started into this maze from the point marked *A*. His food lay in the opening *B*, and the students waited to see whether he would prove himself to be a wise traveler or a foolish one; that is, whether or not he was intelligent enough to remember previous mistakes and profit by them.

Four times each day, and every day for two weeks, this crab was started on his journey. At the first trial he went in and out of the obstructions as the line

indicates, and spent five minutes between entrance and exit; but he shortened his journey little by little each day, until he had made twenty-five trips. He had now learned to take the shortest possible cut across, and within a month he could escape in ten seconds.



READY TO START AGAIN

Another crab was tested by means of a hole in a screen. He was placed on one side, with his food on the other, and he had to get to it by climbing up to the hole on his side, then through the hole and down the other side to his food. I give a nine days' record of the time he spent in making the trip.

	TIME REQUIRED
First day	7 minutes
Second day	4 "
Third day	3½ "
Fourth day	4 "
Fifth day	2 "
Sixth day	1 "
Seventh day	1 "
Eighth day	1½ "
Ninth day	1¼ "

Chickens also teach us lessons in remembering experiences and acting on them. Professor Lloyd Morgan gives the following case:

On giving a humblebee to two Moorhen chicks, one seemed shy of it; the other ate it eagerly. Later, when they were a fortnight old, I threw them two bees, which were seized at once and without hesitation, and shaken violently. One of the birds was probably stung, for he shook his head, scratched the base of his bill, and went again and again to the water and drank. He was all right in about three quarters of an hour, but for about that time he scolded a good deal. The other ate his bee without any evil effects. A day or two after they were given a humblebee from which the sting had been removed, but the bird that had been stung would not go near the insect; the other seized and ate it.

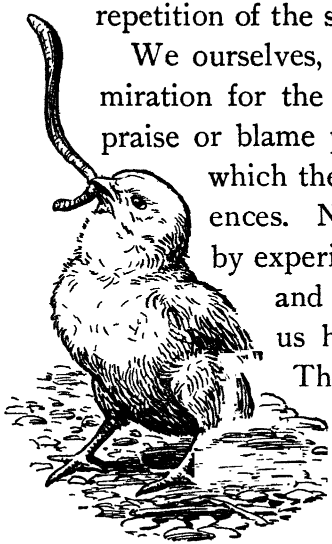
Such cases might be multiplied indefinitely, and each one brings fresh proof that for crabs and chicks as well as for ourselves and all other animals, the center of every intelligent act is this ability to remember — this power which the neurons have to store up experiences for future use.

But how do they do it? How did the sight of a bee suggest the feeling of a sting to the chick? Simply because, as we already know, each set of sense neurons in the cortex is connected with each of the other senses by dendrites and axons; and because messages are thus able to travel backwards and forwards between the different centers. They are closely associated with each other, and the largest combination of senses makes the richest associative memory, as it is called.

Now any creature, from crab to man, that can be helped by this associative memory proves that he has intelligence,

for he learns by experience; that is, he takes different memories into account when he makes his decisions.

The chick took such serious account of his memory of feeling that although his taste memory advised eating the bee, he chose to go without bee flesh rather than have a repetition of the stinging sensation.



No Sting to teach a Lesson

We ourselves, as human beings, carry our admiration for the use of memory so far that we praise or blame people according to the way in which they learn wisdom by their experiences. No doubt we realize that learning by experience lies behind all the choices and all the habits which each of us have.

There is, however, the other sort of memory which comes into play when we study our lessons.

I have two college friends who practice opposite methods of study and have opposite experiences when examination day draws near. One is calm and happy—"Nothing but examination to-morrow," he says, "so I'll go to the woods this afternoon and see how things are growing."

The other is filled with anxiety. "You see, its examination to-morrow," he says, "and I haven't a moment to spare. I'm afraid I'll have to study till midnight,

and, even then, I don't know how I'll get on. It always seems to be such a matter of luck."

These two fellows illustrate two ways of getting ready for each day's lesson. The first man studies for the sake of understanding the subject itself, and he never lets go of a day's lesson until he does understand it. For him, therefore, examination has no terror. The second man thinks more about his daily mark than about having a grasp of the subject. As a result his study is apt to be superficial, and superficial study means that cramming is necessary for any examination which must be passed.

One man goes to his test with neurons rested from a day in the woods, the other goes with neurons tired from a siege of midnight cramming; and the two examination papers belonging to the two men often show which set of neurons has done the better work.

Many a discussion has spun itself hot over the advantages and disadvantages of cramming, and the argument against has won at last. Two weighty reasons against cramming are:

1. It fatigues the neurons, and tired neurons are at their worst so far as doing good work is concerned.

2. That which is learned in haste is forgotten in haste.

This second law rests on the fact that it takes time for neurons to make close connections with each other;

and that, unless they do have time, and are able to make their connections, they are not able to hold on to the mass of stuff which cramming forces upon them. They forget it within a few days or weeks.

In addition to the advantage of making connections, there is still another vital point in this matter of remembering.

Some scientists urgently claim that every sensation, perception, and emotion that reaches the mind changes the neurons somewhat, marking them, as it were; and that these marks, these impressions, are never lost.

They also say that, for this reason, nothing can ever be entirely forgotten, and that our great duty in life is to learn to mark our neurons in such a way that the ideas which the marks represent may come back to us whenever we call for them.

Many surprising facts support this theory. Dr. Carpenter himself gives a case which he calls "one of the most remarkable on record"—especially so because "the patient could never have known anything of the meaning of the sentences she uttered."

In a certain small village in Germany a young woman who could neither read nor write was seized with a fever, and was said by the pastor to be possessed of a devil, because she was heard talking Latin, Greek, and Hebrew. Whole sheets of her ravings were written out and found to consist of sentences intelligible in themselves, but having slight connection with each other. All trick was out of the question: the

woman was a simple creature; there was no doubt as to the fever. At last the mystery was unraveled. They discovered that at the age of nine she had been taken by an old Protestant pastor, a great Hebrew scholar, in whose home she lived until his death. It appeared that it had been the old man's custom for years to walk up and down the passage of his home into which the kitchen opened and to read to himself with a loud voice out of his books. The books were ransacked, and among them were found several in Greek and Latin. In these works so many of the passages taken down at the young woman's bedside were identified that there could be no reasonable doubt as to their source.

Now, in every case, whether marks on the cells have been made consciously or unconsciously, the report which we get from them is called memory. Sometimes we gather these reports easily, and sometimes we get hold of them with the greatest difficulty.

In daily life, when we wish to secure a good memory, our aim should be to mark the cells as thoroughly as possible, and then to connect as many groups as possible with each other. Several definite rules will help in any memorizing which we are trying to do.

1. Understand the subject thoroughly, for only in this way can you be interested in it.

2. Be interested, because only through interest can you compel yourself to give attention to it.

3. Give close attention, because the closer the attention the deeper will be the mark on the cell body, and the more rapidly will connections be made between the neurons.

4. Return to the same subject again and again, looking at it first from one point of view, then from another.

5. Mark and connect as many separate sets of neurons as possible with the same idea. Let neurons of seeing, hearing, and feeling help each other.

This last point shows the advantage of laboratory work whenever there is a chance for it; for the more neurons we can reach and mark, the more roads of connection we can secure, the surer shall we be to get hold of the ideas again when we wish them.

In studying history great help comes from connecting situations that grow out of each other. Take the War of 1812, for example. It was a hard time for England, because she was getting ready for a life and death struggle with Napoleon, the conqueror of Europe. No wonder, then, that her naval captains were tempted to take more sailors from American ships than had actually run away from England; yet that was precisely America's complaint, and she was rather shrewd in making her stand against England at that particular time, for from 1813 to 1814 those great battles were going on which sent Napoleon to Elba and changed the course of European history.

The War of 1812 becomes an interesting and vivid thing when we recall its setting. Indeed, the only way to remember history is to support facts by each other.

As for the way to memorize poetry and prose and lists of disjointed facts and statements, I must give advice by an illustration.

A certain schoolboy was trying to learn some lines of poetry for recitation, and I listened as he worked at it in the usual way — as he said the words over and over half aloud to himself.

> On came the whirlwind — like the last
> But fiercest sweep of tempest blast;
> On came the whirlwind, — steel gleams broke
> Like lightning through the rolling smoke;
> The war was waked anew.
> Three hundred cannon mouths roared loud,
> And from their throats, with flash and cloud,
> Their showers of iron threw.

He put the first two lines together and repeated them from ten to twenty times. The second two followed in the same way. The four were then given together many times, and the fifth was added.

It seemed to me that, at this rate, each line of the poem would be repeated a hundred or a thousand times before the boy was through with it. This was pitiable, and I had a great desire to help him.

"Is that the way you always do it?" I asked. "Do you memorize by simply saying words over and over again ten thousand times? "Certainly," he answered. "And when you think you know it, are you perfectly

sure you can't forget it?" "No, I'm never perfectly sure," he said again. "How can I be, when I've such a wretched verbal memory?" "I'll help you then," I exclaimed; and my instructions were about as follows: "In the first place, instead of rattling words off as if they were beads on a chain, fasten your mind on them separately, one by one, phrase by phrase. Read very slowly, think of the meaning, and at the same time make a picture in your mind of the thing described. Imagine you see the whirlwind coming, that you hear the sweep of the tempest blast. In other words, be interested, and at each step press as many sets of neurons into service as you can get hold of by any pretext whatever; mark them as clearly as you can.

"Then, too," I added, "you'll probably need to make some bridges. Do you have special trouble anywhere?" "There's one place," he said, pointing to the sixth line. "I go along well enough until I get there; then I stick."

I saw what the trouble was. There was nothing at the end of "waked anew" to suggest the next line. "Ah," said I, "you reach a chasm just there; you'll have to bridge it. You might connect 'waked' with 'cannon.' Do it in this way; when you reach the word 'waked' think how quickly you would waken if three hundred cannon mouths roared loud near your bed; and when you reach 'cannon mouths' be ready to join it to 'throats' because throats and mouths suggest

each other. For the line after think of 'showers' that fall from 'clouds.' Make sensible bridges when you can, but even a foolish bridge is better than a chasm."

The boy caught the idea at once, and began to make bridges for himself. "My! It's a great scheme!" he exclaimed. I told him that the reason these bridges work so well is because ideas always follow each other best when they suggest each other; in other words, because associative memory helps. Every chasm between words or phrases is therefore made easier by a bridge which will connect words or ideas. I told him he could use the same scheme for learning topics in history and literature. He tried and succeeded.

Indeed, this one lesson on memorizing started a new era for the boy. He gave up the parrot method of learning by a thousand repetitions and adopted the scientific method of taking the laws of the mind into account; and now, when he wishes to learn anything by heart, he is careful to mark his neurons, to make good connections between them, and to build bridges wherever this is necessary.

As a result, he now memorizes either poetry or prose in less than half the time formerly required. Moreover, he has given up all talk about his "wretched verbal memory," while his friends speak of him as having "such a good memory."

CHAPTER XXV

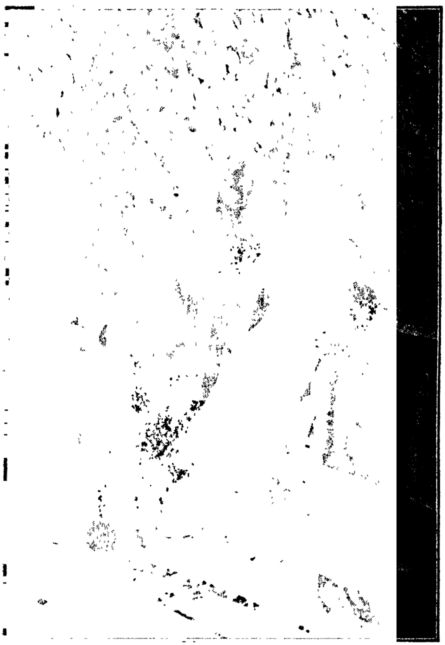
STEPS TO TAKE, OR CHOICE, ATTENTION, AND WILL POWER

A few evenings ago, as I walked down the street, I heard my young neighbor calling, "Buster, Buster, Buster." At the same instant I also saw the outline of the small, brown dog himself just across the street. He had stopped running away from home, and was listening to the voice which came to him from half a block away.

He seemed to be trying to decide what choice to make — whether to obey at once and go home, or to keep on running away for the fun of it. I saw that, as he listened, his three-quarter length stiff tail had stopped its happy wiggle and that it stood out straight and firm on a line with his backbone; only for a few moments, however, for soon it wiggled again, rather saucily I thought, for the dog now trotted off in the running-away direction, and his tail, as it waved, seemed to say, "Fun first."

But the call continued — "Buster, Buster, Buster, Buster." He stopped again, listened once more, made another choice, then, rather reluctantly, quite slowly, and with a very quiet tail, turned and went home.

Somehow I felt as if Buster had won a moral victory for himself. He had chosen to give attention and to obey, although he knew that his mistress could neither see him nor reach him.

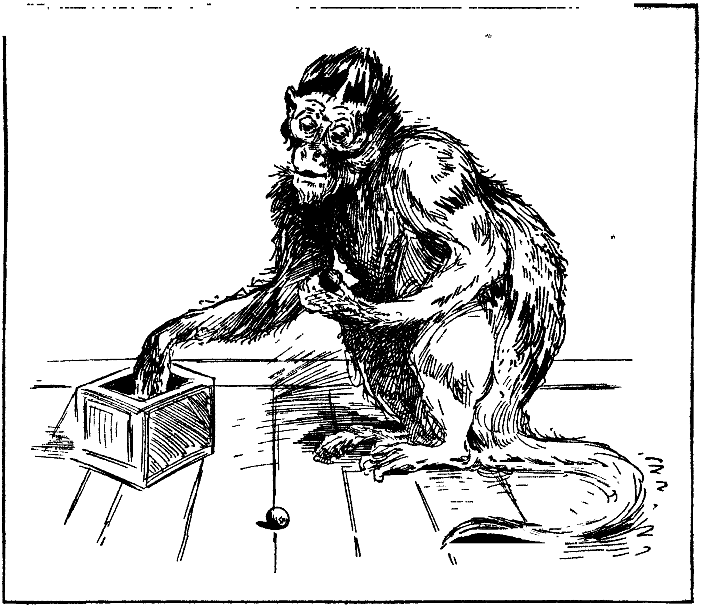


BUSTER AND HIS MISTRESS
Each pays attention and makes choices

Charles Darwin, in his book, *The Descent of Man*, tells a story about attention in connection with monkeys. It seems that a certain Englishman used to buy monkeys from the London Zoölogical Gardens, and that the regular charge for them was twenty-five dollars apiece. Instead of selecting a monkey according to its beauty, however, according to its size, or its ability to climb, the man always offered twice as much for the one he should finally buy, if only he might be allowed to take three or four of the chattering creatures home with him for a few days.

It appears that the man trained monkeys to be actors; that some could learn their parts in the play,

that others could never learn, and that he himself could tell which would succeed and which would fail by the sort of attention which they gave when he tried to teach them anything. If the monkey was not interested, if his



He gives his Best Attention as he tries to learn to Count

attention was easily distracted, if, in the midst of a lesson, he stopped to notice passing flies and such trifles, why then the case was hopeless; that particular monkey would never make an actor. He had lost his opportunity; he must be sent back to his aimless life in the gardens.

It is evident that human beings differ quite as much among themselves as do the monkeys; and that, for men no less than for monkeys, the value of attention cannot be overstated. But we should remember that attention is vitally connected with interest and will power; that the three are indeed but different sides of a single mental act; and that by our knowledge of this fact we may do wonderful things for ourselves through any one of our senses. Take, for example, the well-known case of Robert Houdin. Years ago he delighted the world with his power to remember what he saw, and he trained his son until he too excelled.

Houdin began this training with dominoes. First he laid one on the table, and, by a glance, without counting, the son was to tell how many spots were on it. Two dominoes followed; he was to tell how many spots the two together had. Each day one domino was added, until twelve were on the table at once, and father and son were able to tell at a glance, without counting, how many spots the whole number contained.

Next came training by means of a shop window full of toys. They walked past it fast, looked attentively as they went, and, having passed it, they wrote down at once all they could remember having seen in it. This practice continued day after day, and in the end the son outdid the father. He could recall forty-eight different articles against the father's thirty.

Taking this power into account, Robert Houdin concluded to surprise his audience with it some evening. The time came. As father and son entered the house where the exhibition was to be, they passed through a well-stored library; and, turning to his son, the father advised him to notice the titles of some of the books, and where they stood on the shelves. The men then gave their regular exhibition, and the surprise followed it. The rest of the story must go in Houdin's own words:

"To end the second-sight experiment, sir," I said to the master of the house, "I will prove to you that my son can read through a wall. Will you lend me a book?"

I was naturally conducted to the library in question, which I pretended now to see for the first time; and I laid my finger on a book. "Emile," I said to my son, "What is the name of this work?" "It is *Buffon*," he replied quickly. "And the one by its side?" an incredulous spectator hastened to ask. "On the right or the left?" my son asked. "On the right," the speaker said, having a good reason for choosing this book, for the lettering was very small.

"*The Travels of Anacharsis the Younger*," the boy replied. "But," he added, "had you asked the name of the book on the left, sir, I should have said, Lamartine's Poetry; a little to the right of this row I see Crebellon's Works; below, two volumes of Fleury's *Memoirs*"; and my son thus named a dozen books before he stopped. The spectators had not said a word during this description, as they felt so amazed; but when the experiment had ended they all complimented us by loud plaudits. — *Autobiography of Robert Houdin*, p. 206.

There was nothing strange in all this. The Houdins simply used ordinary eyesight, and, by close attention,

trained themselves to see and to remember what they saw. Their success teaches us how we too may help ourselves.

During each moment of our waking lives our interested attention is centered at one point or another. From babyhood upward there is no such person as a sane human being who gives attention to nothing. Unfortunately, however, there do exist people who seem to lack the power to fasten their attention on the same thing long enough at a stretch to accomplish anything with it.

Almost any school proves this. I visited one recently for no other reason than to look into the subject, and I had my reward. On entering, I noticed two boys seated near each other. One seemed to see nothing that happened in the room. His arithmetic was open before him, his fingers were busy with pencil and paper, he did not lift so much as an eyelash to see who came and went through the doorway.

The other boy had an open arithmetic too, also a lead pencil, which he sometimes acted as if he intended to use. But at every noise his eyelids flew up. He raised his head and even stretched his neck round awkwardly to follow comers and goers and their movements. He sharpened his pencil, made signs across the room, looked at the clock, wound up his watch, moved restlessly in his seat, snapped flies. In fact, no monkey could have been more easily diverted from his lesson than was this boy from his arithmetic.

Turning to the teacher, I asked who the boy was. She gave his name, and said: "Rather a pleasant fellow, but I'm afraid he'll never amount to much. It seems impossible for him to hold his attention to anything he is studying. He isn't interested." I thought of the monkey and wondered if the boy too might not be losing his great opportunity.

"Who is the boy next to him?" I asked. She laughed and said: "Isn't it queer! There they sit side by side, the best student and the poorest student in the room. But the queerest thing is that the best one spends the least time on his books. He is catcher for the class team, and he seems to have learned the secret of saving time by giving close attention to his books while he is at them."

I looked again, and, sure enough, he was still giving attention. But now he was studying German instead of his arithmetic.

Those who study attention from the standpoint of experiments have invented various pieces of apparatus, and through them they discover what special conditions interfere most with the power of attention and what conditions are most helpful.

One test was with a man who sat in a room with an organ. He was to press an electric button with his right hand on the instant that he felt something touch his left hand. When the organ was quiet the stimuli

traveled so fast upward to the brain from the hand, then down to the other hand from the brain, that the time which elapsed between the touch and the button pressing was only one-hundred thousandths of a second. When some one played the organ, however, it took

HIS LEFT HAND WILL BE TOUCHED; HIS RIGHT WILL PRESS THE BUTTON

When he is touched the long pendulum will begin to swing. When he presses the button the short pendulum will also swing. The time it takes the short one to overtake the long one will show how long it took the stimulus from the left hand to go to the brain and then to be sent down as a command to the right hand

almost half as long again for the stimulus to travel. The apparatus showed that it had now spent one-hundred and forty-four thousandths of a second on the way.

In both cases the man gave his closest attention to the touch which he expected to receive, and he pressed the button as promptly as possible. It was clear, therefore, that noise distracts attention and hinders work.

Similar tests, with other kinds of apparatus, have been made for each separate sense; and men have learned that noise, confusion, and fatigue interfere with the ability of attention to do its best work. Good teachers know these facts and act accordingly. They always insist that their school shall be quiet and undisturbed. They are also careful to take up earliest in the day studies which need the closest attention; and they take pains to sandwich difficult lessons between those that can be done with less attention. Their reason for this last arrangement is that real mental fatigue must be avoided if students are to use the power of their attention to their own best advantage. They know that as india rubber loses its ability to contract when it is kept on the stretch too long at a time, so too will attention fail if it is stretched too persistently. Yet exercise of attention is as useful in increasing mental power as exercise of muscle is useful in increasing physical power.

Groups of college boys were out of doors, standing in rows, dressed in running outfit, waiting for the signal, ready for the race. Some were bent forward, hands and arms down, bodies tense. They intended to start with a jump.

Others stood straighter, but with feet in position, elbows crooked, every nerve keenly strung. All were silent, for every thought was fastened on the expected signal. Attention was written on each intense face and

body. Each man knew that the closer the attention he gave, the swifter the start would be, and the better the chance for winning. The signal sounded and all were running; but, even from the start, some outstripped the others.

Without saying much about it, we all know that attention is a power which belongs quite as truly to large

THE CLOSER THE ATTENTION, THE BETTER THE START

matters, and to the whole of life, as to races and school work. It is, indeed, a power so tremendous in its influence that no one may set a limit to what he himself may accomplish in any chosen direction, provided he is willing to focus his attention just there.

It was attention to touch that won success for Laura Bridgman. It was attention to the laws of public speaking that made an orator out of the man Demosthenes. It was attention to microbes and to the laws of life that

made it possible for Louis Pasteur to save the silk industry of Europe. It was attention to other men's discoveries about malaria and mosquitoes that led scientists to discover the cause and deliver men from the terror of yellow fever; and so on, through the list of great men and their great deeds and discoveries. Always and everywhere attention is the foundation of human success.

The thing we attend to is the thing we attain to. And this brings us back to the great subject of choice with which the chapter started. We have seen that interest and attention travel hand in hand; that they cannot be separated; that they grow through adjustment to circumstances, and that will power is, in a way, attention under another name.

It is evident, then, that these three working together show themselves in what we choose. And the solemn side of this fact is that character itself is built up of choices. Moreover, each separate choice is influenced by all the other choices that have gone before. Thus, little by little, through one choice that follows another, characters good and bad, characters strong and weak, get their final shape.

Thousands of human beings in all parts of the world are to-day making careful choices and shaping their lives according to some high purpose. They have said, "I can" and "I will"; they have learned the secret of close

attention to what they have chosen; they have turned away from feelings and desires which they know will mean nothing but brief, present pleasure, and have chosen to attend to such things as will mean enormous gain in the long run.

There are multitudes of other people, however, who shift and drift through life, making accidental choices, feeling no interest in what they themselves may become. Such men and women are the weak ones and the failures of the race.

We prove what we are, then, by the choices we make, for these show what we are doing for ourselves through interest, attention, and will power.

CHAPTER XXVI

EFFECT OF DRUG AND DRINK ON BRAIN AND CHARACTER

In the year 1907 the imperial government of China forbade the sale of opium throughout the land. Messengers carried the news far and wide; posters proclaimed it in town and hamlet, and everywhere the people rejoiced when they heard the tidings. Yet no printed poster told why the Chinese were glad to be rid of their opium, nor gave any itemized list of the ways in which opium had harmed them. No such list was necessary in China, for, in certain regions, men and women on every side declared by their looks and their acts what it was they suffered.

With experience enough, we ourselves would be able to recognize the man who is destroying himself with opium. Very thin he is, his skin loose over his bones, his face pale or ashy gray; a man with no appetite, with a hoarse voice, an unsteady hand, and disturbed speech; a man depressed, unable to do brain work. But, worst of all, such a man is known by his character; formerly he may have been a man both reliable and

JOYFUL THANKS FOR PROHIBITION OF OPIUM

The injury done by opium is very deep and very great. Last year on the 3rd of the 8th moon an Imperial Edict was issued prohibiting and the government gave opium dens a limit of 6 months to stop their business and close their doors. Now the 1st of the 4th moon is the limit for closing and stopping the business of our Min Province opium dens. All our countrymen on that day should unfurl the Dragon Flag and together rejoice and give thanks. Fukien is fortunate! All China is fortunate!

Copy of a Yellow Chinese Poster, Five Feft Long, and its Translation

truthful; now no dependence is placed on his acts, and his word is never trusted.

One morning, years ago, a woman came to see me, wearing a long gray cape. As we talked she threw back her cape and said, "See my back." I saw that it was pitiably deformed, and I said, "I'm very sorry."

"Will you help me get it cured?" she asked. "The doctors say they can straighten it for me if I will go to the hospital. I need money to meet the bills." I was glad to help. But a few weeks later I heard that the woman used opium every day, that she secured it in dishonest ways, and that her plea about having her back straightened was one of them.

I was also told that the start of it all was from opium which a doctor had given her to relieve pain. First it was pain to be conquered, then it was the habit which conquered her life and blighted it forever. She paid too high a price for her pleasure. When it was too late she herself saw that she had sacrificed infinitely more than she had gained by it.

Thus it appears that opium not only weakens and depresses the neurons, shattering the health of the body, but that it changes these neurons in the awful way which means a ruined character.

Doctors know so well how swiftly and silently the opium habit may steal upon a man that the wisest among them are careful never to give a dose of it unless the need is very great. When used once in a long while, for intense pain, opium is one of the greatest blessings that a doctor carries to a suffering man. Otherwise it is a curse. Through it millions of human beings have been destroyed body and soul. They might have saved themselves had they known the danger.

Yet even the curse of opium is outstripped by that of alcohol. Read the following list of crimes which Dr. Crothers gathered from a few papers of a single day.

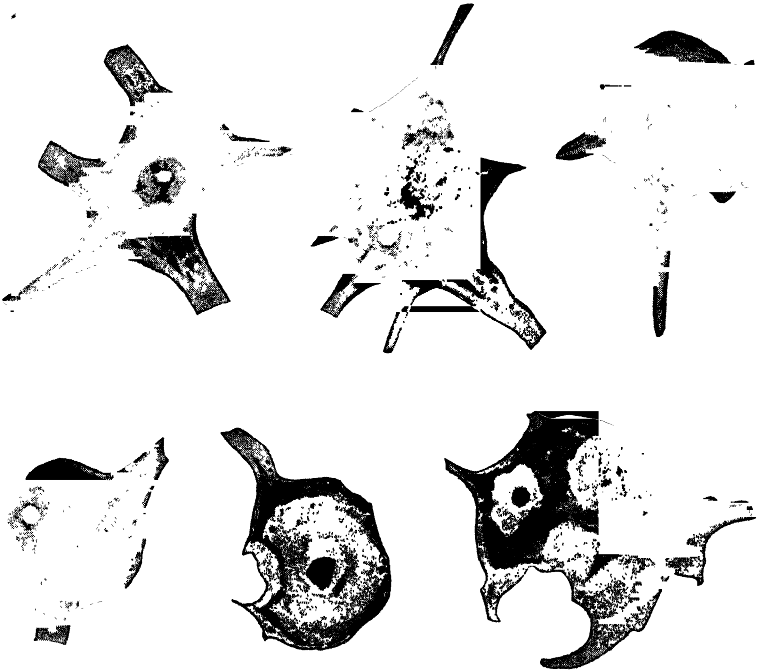
An inebriate, of previously quiet disposition, killed his wife, supposing she had put poison in his food. Another man, in a similar state, shot a stranger who differed with him on the age of Queen Victoria. Another man killed his father, who remonstrated with him for overdriving a horse. Still another fatally assaulted his brother, who would not give him money. Two men, both intoxicated, mortally wounded each other in a quarrel as to who should pay for the spirits drunk. Another man killed wife and child, supposing the former was going to desert him.

Notice the contrast between what opium does in ruining the man himself, and what alcohol does in leading a man to injure others as well as himself.

The man who uses opium to excess is not brutal. His own character is ruined; his body shrivels away like that of a mummy, but he does not lose his reason; he neither kills his wife nor murders his children. No; the horror of such crime lies heaviest against the door of alcohol. The number of these deeds in different countries is closely connected with the size of the drink bill, and everywhere facts and figures show how enormous the bill is in all lands.

The outcome of this flood of alcohol is, of course, that crime and drink live together in our cities. We

learned about this partnership in *Town and City*. This book, therefore, needs to show how it is that alcohol is able to transform human character as it does.



CELLS FROM THE SPINAL CORD

The upper cell at the left is normal, with its nucleus in the center The upper cell at the right is dead, it has no nucleus whatever The other cells are swollen and the nucleus is pushed far to one side These diseased cells were taken from alcoholic persons who died in Claybury Asylum, England They were drawn by Dr Mott for Sir Victor Horsley

The chapter on Cell Poisons shows what alcohol does to single cells and groups of cells; but now we have

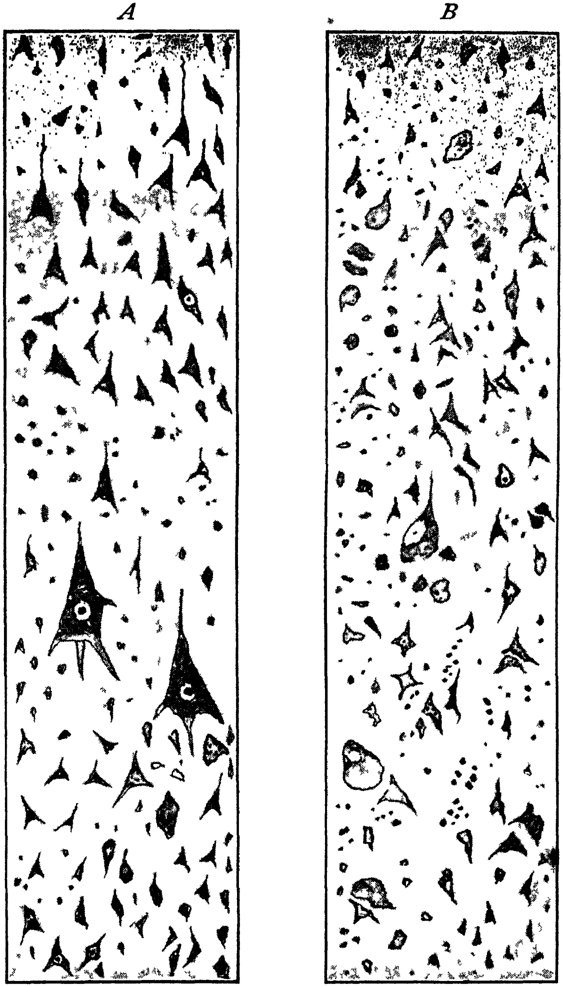
arrived at a more critical point. We are to see that, of all cells which alcohol damages, it is precisely those which are most sensitive and most important to us that suffer most.

Examine the illustrations one by one. Compare the normal cell, taken from a healthy spinal cord, with those taken from the spinal cord of a person who had killed himself through alcohol. Notice the swollen condition of the cells, the nucleus pushed to one side, the material of the cell itself broken up as if it were diseased. A cell without a nucleus is not simply diseased; it is dead. One such is given.

Look at the illustration from the healthy brain. Compare those clean-cut, trim, normal cells with the ruined cells taken from the brain of an alcoholic person.

An important fact in this connection is that the dendrites are the first part of a neuron to be injured by alcohol. They grow soft; they swell; these swellings enlarge and multiply until multitudes of dendrites on numberless groups of neurons are so changed that they look — as Dr. Cutten says — like the diseased branches of a plum tree when the "black knot" is destroying it. This diseased condition grows constantly worse as the use of alcohol is increased in quantity.

Without any words of explanation, then, we see for ourselves what must happen to a brain when its dendrites are not healthy enough to do their work well. Memory



CELLS FROM THE CORTEX FIBERS NOT GIVEN

A, cells from a healthy brain; *B*, cells from the brain of a victim of alcohol. Notice the changed shapes, smaller size, and diminished number. They are the record of a brain wrecked by alcohol. — After Horsley

fails because the neurons are losing their connections with each other. Close attention becomes impossible, because when connections are lacking will power is weakened. Reason halts because a man cannot think clearly when neuron connections are broken.

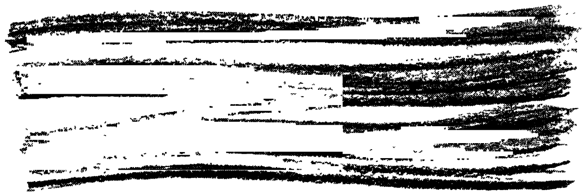
He who insists on weakening the power of his neurons through alcohol is responsible for all that must follow. He is damaging the finest, the highest part of his nervous system, and he who does this weakens himself in brain and character.

No instrument has been discovered which can detect the progress of the disease of the neurons. Even the X-ray cannot take a picture of them. Nevertheless a man shows quite plainly what the state of their health or weakness is by what he succeeds in doing through his brain and his character.

Study the bundles of nerve fibers too, and when you see clearly what has been done to them as well as to the neurons, speculate about the sort of work we have a right to expect from cells and fibers that have been poisoned and hopelessly injured by alcohol.

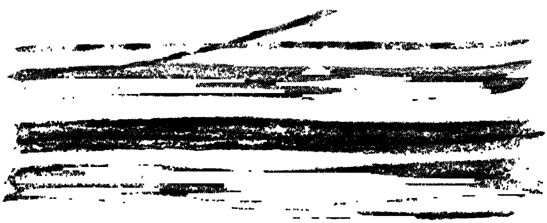
With such cells and such fibers as that to guide a man's life, is it strange that self-control slips away; that ambition goes too; that high deeds are impossible; that thoughts of right and wrong get mixed; that brutality becomes possible; that crimes are committed; that lives are wrecked; that character is transformed?

The amount of damage done to the neuron by alcohol depends partly on the nature of the person who drinks, partly on the amount of alcohol he takes. In every case, however, alcohol is a poison for the neurons. He, therefore, who drinks to the health of his king or his friend drinks not only to the success of disease microbes in his own body — as shown in Chapter IX — but he also drinks to the ill health of his most precious helpers, the neurons of his body.



NORMAL NERVE FIBERS

It is a strange fact that when neurons become thus diseased by alcohol, the one thing which they most earnestly call for is more alcohol; and this introduces a very serious objection to the regular use of even small quantities of alcohol taken in any shape. In multitudes of cases the mere fact that a man has taken a little once in a while has put his neurons into such a condition that they have called for more and demanded it more often. Indeed, even when the neurons were not



NERVE FIBERS AFFECTED BY ALCOHOL

yet diseased, the more they have had the more they have wanted. After this has gone on for some time, and after the neurons are once diseased, nothing will content them but alcohol. Yet by the use of that very alcohol the disease becomes steadily more and more serious.

In the meantime, however, the man himself may not see that a subtle weakness is undermining both the power of his brain and the strength of his character. In most cases he even thinks that he is enough of a freeman to stop taking alcohol at a moment's notice, if he should decide to do so. He cannot examine the cells of his own brain, and he does not know that his will power has been conquered by his diseased neurons.

But when some day he suddenly wakens to the discovery that he has undermined the power of his brain and weakened his character, he may wish to separate himself from the cause of his weakness. By that time, however, he may also find that already he is the hopeless victim of diseased neurons, that the alcohol habit is his master; and surely no discovery that a man ever makes about himself can be a sadder one than that.

CHAPTER XXVII

BUNDLES OF HABITS

The man himself was well dressed; he carried a gold-headed cane, wore a silk hat, and walked the streets of London as if he had always been there.

Two other men passed him, and the younger said: "Rather a queer walk, wasn't it? A bit of a drag to one foot—not really lame, though, was he?" "No, not lame," was the answer, "simply a habit. I know the man. He spent twenty-five years of his life in prison with a ball and chain fastened to his right foot. The weight dragged it then and habit drags it now."

"Can't he help himself?" was the question. "In a way, yes. When his mind is actually fixed on the subject he walks as well as you do. But the moment his mind wanders, the moment he forgets himself, his old habit steps in and his foot drags."

"How did he get out of prison?"

"Well, you see, he was innocent after all; but they didn't know it for twenty-five years, and then they hurried to let him out. They wished to make amends, but already firm habits had been formed."

"He isn't to blame for his dragging foot then?" "Not in the least, but it drags just the same." The two men passed on, but the lesson of that story can never be forgotten.

Habits of bone and muscle cling to us through life, whether we are to blame or not to blame for their establishment.

A friend of mine proved this in his own case. He had lived in Japan for thirty years. He then returned to his native town in Ohio, and from behind one day he heard the call: "Well, I declare! If that isn't John Mills! I'm glad to see you back." Mr. Mills turned, laughing, and said: "How do you know me? I've been away for thirty years, and even now you've only seen my back."

"Quite enough," was the answer, — "quite enough; I'd know you anywhere by your walk."

Multitudes of other people also betray themselves unconsciously. Judge this for yourself. Stand at a street corner some day and watch the people who pass by. If you have had any experience in this kind of examination, you will soon learn a fact or two about most of those whom you see. By their habits of walk and of expression; by their habits of gesture and of speech; by the way they wear their clothes and greet their friends; by a dozen small signs, you will come to some general conclusion about the occupation of each one who passes you.

Soldier, sailor, farmer, lawyer, carpenter, preacher, shopkeeper, commercial traveler — each occupation seems to betray itself in close line with that which the muscles proclaim by their habits.

Dr. Carpenter says that our organs grow to the way in which they have been exercised; and Professor James says that we are all bundles of habits. No wonder, then, that by the time a man is thirty these habits are revealing unmistakable facts about him. He himself may, however, be entirely ignorant of their declaration. There are, in fact, men who have such high respect for their will power and their power of choice, that they expect to be able to save themselves from any chance habits at any time.

A high-school friend of mine used to be of this opinion. In a talk one day he said: "I don't believe there really is such a thing as habit. I can do the same thing in the same way as long as I please, and then when I want to change and do something else, I just change and do it."

"Do you mean walking crooked and all?" I asked. We both smiled, for he was standing crooked at that moment. "Certainly," he said. "I do it for fun most of the time. But when I go to church I just stand up and I'm as straight as anybody."

"I fear," said I, "that that notion will be your destruction; for the sad fact of the case is that, even now —

and you are only fifteen — when you are straight, as you call it, you are not quite so straight as you were a year ago. You'd understand at once if you could get a side view of yourself in a mirror. It isn't simply a case of muscle, you know; it's bone that is bending, and bone is so hard that when it is finally set it is firm for life. Even dendrites and the cerebellum, even the commands of the cerebrum, will do no good after that."

The boy looked rather serious, and I notice that since then even his week-day walk has improved.

My poor grandmother never succeeded in straightening her back. She saw what she had done to it when it was too late to make any change.

An old neighbor used to say: "Stand up straight! stand up straight! else when you're old you'll be as bent as your grandmother." This meant a good deal to me because, although I loved my sweet-faced grandmother dearly, I felt great pity for her. Somehow I thought she had always been that way, but my friend said: "Oh, no, not at all. When she was in school she was as pretty and slim and straight as anybody; but she always sat at her desk with her back and shoulders curled over, as it were. Then, finally, she began to stand and walk that way, and you see what it has come to. She's a good woman; but it's awful to have a back like that when you might have had a straight back as well as not."

The serious side of this whole affair is that when a habit is forming in any direction it creeps upon us so slowly and silently that we get no warning of its approach. The explanation for this lies nowhere else than with the neurons themselves, for, as a rule, they learn lessons rather slowly.

To sit with curved back once did my grandmother no harm; neither did the second time or the third time signify very much. But each day made the list of times longer; each was a lesson repeated once more, until at last bones were permanently bent, while muscles and tendons were in the firm grasp of neurons that had learned their lessons perfectly. They did the thing they had been taught to do.

It is clear, then, that for every habit there is a time when it can be checked, and also a time after which it is as firmly fixed as the stature of a man or the shape of his head.

The way a man sits and stands and walks; the way he eats and drinks and talks; the way he smiles and laughs; the way he teaches or preaches, drives his horses or his engines, hammers nails or holds his gun — each way he has for doing each separate act of his life is the result of having done it in that same way over and over again until that particular method has become a habit.

As a result we judge each other by our habits, and we are justified in doing this. For, whether each was started by a definite choice or not; whether will power was used

to force attention in certain directions or not, the fact remains that will power did not interfere to overcome bad habits. And we blame a man almost as severely for what he might have done with himself, and failed to do, as for the things that he did do with deliberate purpose. If he is untidy, slovenly, rough in his manner, loud voiced; if he loses his temper or talks through his nose, or drawls or contorts his face when he talks; if, in any direction, he does such things as make him unattractive to us and different from those whom we admire, we rate him accordingly.

Each of us will, in fact, always be liked or disliked according to our habits. We shall succeed or fail according to these same habits. Sometimes those that may seem unimportant will have great influence.

A certain man was such a fine scholar and such a strong character that an eastern college talked about asking him to join its ranks as a teacher. Before all was settled, however, the man was invited to dine with several members of the faculty of that college. After that, nothing more was said about his coming there to teach. Why was the subject dropped? Simply because his habits at the table were so rough and unfinished that those other men knew it would be a mistake to set him up as an example before students. His table habits defeated him. Yet they were formed almost before he was old enough to think about them.

It is in this matter of early habits, then, that the responsibility of parents is greatest; for, as a rule, for weal or for woe, the habits of the young are the habits of their parents.

In talking about this whole matter with a friend the other day, she said: "If mothers only knew! Why, I grow alarmed when I see a child doing anything in the wrong way twice in succession. It simply means that a habit is beginning. And if mothers were kinder, they might save their children so much afterwards. Here is Eleanor an illustration of my own folly. I always combed and braided her hair for her until she was twelve years old. Then I put it into her own hands, and now she can't remember to take the combings from the comb when she is through. She wishes to do it, and always has to pay her penny fine when she forgets. I also wish it, and she is anxious to please me. Her will and my will are united in the struggle against that one small habit; but, as yet, we haven't conquered. If I had only had her take the hair from the comb, even while I was helping her, she would have had that habit by this time, and all this energy of our wills could now be spent on something else."

This is a practical, everyday illustration of the way in which many habits are started in childhood. They are the result of oversight or of ignorance; yet the mischief is as thoroughly done as if it were intended. Fortunately, however, the way of escape is within ourselves.

CHAPTER XXVIII

FREEDOM AND SLAVERY

An acquaintance of mine has a curious way of getting material for the best articles she writes.

She keeps paper and pencil in her bedroom, and even while she dresses in the morning she stops abruptly at almost any point and writes as fast as she can for a few minutes, then goes on with her dressing. She says she can do this because everything, from exercise and bath to nail cleaning and necktie, steps along so much as a matter of habit, so entirely in its usual order, that she pays no attention to what she is doing, and that her mind is thus released for thoughts about her writing.

A child, whom I also know, carries out an opposite plan, which wastes nervous energy every morning. Nothing goes by routine in her life. She makes decisions at every point. "Is it really time to get up?" she wonders. "Surely five minutes longer won't matter." "Isn't the water too cold for a bath?" "How about leaving teeth until after breakfast?" "And finger nails — can't they wait too?"

Each question has to be settled on its own behalf, and thinking neurons use up energy and force in directions where they should be released from all responsibility — where one act should follow another almost unconsciously.

Routine work during each day of our lives is, in point of fact, the salvation of the nervous system. Moreover, habit is the friend that makes routine possible.

A child who has formed the habit of quick obedience saves himself wear and tear by always obeying promptly. A boy who has learned how to focus attention when he studies saves himself hours of time.

If practice never made it easier to walk or to run, to ride or to swim, to lace a shoe, untie a knot, or braid the hair; that is, if neurons were unable through practice to learn lessons or to form habits, neither we as individuals nor the human race as a whole would ever be free enough from small things to make progress in large affairs.

"Freedom," as I use the word, means ability to do things without giving each separate one of them a conscious thought. The opposite condition, slavery, means the unconscious doing of that of which we disapprove. In other words, habits of which we approve make us free, while habits of which we disapprove hold us in bondage.

Whether for slavery or for freedom, all habits are formed in one or the other of the following two ways:

1. By frequent repetition.

2. By some sudden, unexpected, strong impression.

The former is the usual way, as was seen in the last chapter. But there are cases where a permanent habit is formed within the flash of an instant.

As my brother started to run up a low cellar stairway, he knocked his head with a bang against a projecting beam. Quickwitted neurons learned their lesson without delay; the habit was formed, and thenceforward, for years, although the beam itself had been taken away, he found that his head always dodged when he started to run up that particular stairway.

In cases where habits are formed slowly a little knowledge helps.

A friend tells me that although his mother saw to it that he brushed his teeth every morning of his life until he was ten years old, still he himself was ready to forget his task any day until he learned about microbes and knew why teeth should be washed. His own choice then stepped in as a habit-forming help, and now he says that the habit of teeth washing is firmly established. He does it as a matter of course, never stopping to discuss the question and never forgetting.

Both knowledge and choice are seen to be helps in forming habits of various kinds. But what about other habits? What about those that mold character itself?

I am thinking now of those internal habits which mold us so completely that even the expression of our faces is altered by them — habits which finally become so truly a part of us that they are at last the truest self, the self which is quickly recognized wherever we go. I give a few of these contrasting habits in columns which face each other.

Habits of truth	Habits of deceit.
Habits of courage	Habits of fear.
Habits of persistence	Habits of neglect.
Habits of attention	Habits of inattention.
Habits of kindness	Habits of cruelty.
Habits of appreciation of others	Habits of scorn for others.
Habits of thriftiness	Habits of shiftlessness.
Habits of order	Habits of disorder.
Habits of cleanliness	Habits of uncleanliness.
Habits of diligence	Habits of idleness.

The list might be made almost endless, for it should cover each separate habit of mind and character that a human being may own. We should bear these character habits in mind, for each lies within our grasp; each is placed by our own hands in the column which we are piling up for ourselves — the column which shows what we are. Look over the printed list, locate your own habits, decide whether they are in the column which pleases you or in the other column, and make up your mind as to whether or not, in your own case, you think it worth while to make any changes from one column to the other.

For the sake of helping those who propose to do some transferring, I give three laws which Professor William James lays down for the guidance of college students. These laws seem to me quite as important for children as for those who are older, and I give them as nearly as I can in the words which Professor James himself uses.

1. In starting a new habit, or in leaving off an old one, launch yourself with as much vigor as possible. Do everything that will make right motives seem more convincing; surround yourself with conditions that will encourage the new way. Make a public pledge, if this can be done; in other words, surround your new resolution with every help you know anything about. All this will give you a good start. It will help prevent a breakdown; and every day which postpones a breakdown increases the chance that you will carry out your purpose.

2. Never make an exception to your rule till the habit is well rooted. Each exception, each lapse, is like dropping a ball of string that you are trying to wind up; a single fall undoes more than a great many turns will wind up again. Persistent training is the one surest way to get the nervous system to do as you wish. Never lose a battle. Every gain on the wrong side undoes the good of many conquests on the right. The great point is to secure such a series of successes that old habits become

weakened, while new habits gain strength through constant victory.

3. Seize the very first possible chance you have to act on every resolution you make. No matter how good your resolutions are, if you do not avail yourself of every chance to *act*, your new habits will not be formed; your character will remain entirely unaffected for the better.

These three points put in a nutshell are as follows:

1. Start with vigor; strengthen yourself by every possible aid.

2. Never make an exception. Never lose a battle.

3. Seize every chance to act out your new resolutions.

Professor James also writes these other solemn words for his college students to remember, and I give them precisely as they are printed in his great book.

We are spinning our own fates, good or evil, and never to be undone. Every smallest stroke of virtue or of vice leaves its never so little scar. The drunken Rip Van Winkle in Jefferson's play excuses himself for every fresh dereliction by saying, "I won't count this time!" Well, he may not count it, and a kind heaven may not count it, but it is being counted none the less. Down among the nerve cells and fibers the molecules are counting it, registering and storing it up to be used against him when the next temptation comes.

Nothing we ever do is, in strict scientific literalness, wiped out. This has its good side as well as its bad one. As we become permanent drunkards by so many separate drinks, so we become saints in the moral

and authorities and experts in the practical and scientific spheres by so many separate acts and hours of work. Let no youth have any anxiety about the upshot of his education, whatever the line of it may be. If he keep faithfully busy, he may leave the final result to itself. He can, with perfect certainty, count on waking up some fine morning to find himself one of the competent ones of his generation, in whatever pursuit he may have singled out. Silently, between all the details of his business, the power of judging in all that class of matter will have built itself up within him as a possession that will never pass away. Young people should know this truth in advance. The ignorance of it has probably engendered more discouragement and faint-heartedness in youths embarking on arduous careers than all other causes put together.

CHAPTER XXIX

THE CASE OF THE CHILDREN AGAINST CELL POISON

For years teachers have been wondering why some children are dull and others bright in school; why some remember where others forget; why some are healthy and others diseased; why the power of will is strong in some, weak in others.

These and other questions have been asked a thousand times. But, even yet, the full answer cannot be given. Certain investigations, however, have thrown a good deal of light on the subject.

Dr. Bayer, director of a primary school in Vienna, Austria, studied the habits of the five hundred and ninety-one boys and girls in his school, and thought he had found some excuse for the dull ones. He published his discovery so that other teachers and pupils might know how to change their records if they cared to.

In Austria beer is the great standby as a drink, and this table shows what relation there seemed to be between the scholarship of those Viennese children and their beer-drinking habits. Do not try to remember the tables given in this chapter, but remember the lessons they teach.

EFFECT OF BEER ON SCHOLARSHIP

Class of Pupils	Grade of Scholarship		
	Good	Fair	Poor
Abstainers from beer (in each hundred) . . .	41.8	46.2	9.0
Occasional drinkers of beer " . . .	34.1	56.6	9.5
One beer daily " . . .	27.8	58.4	13.3
Two beers daily " . . .	24.9	57.7	18.3
Three beers daily " . . .	—	33.3	66.6

Notice how the proportion of dullards mounts upward on the last column as the beer increases. Three beers a day seems to have put two thirds of the drinkers in the lowest rank. Still the number here was very small.

No doubt some of these children had been studying hard and had wondered why they could not learn their lessons as well as their friends did. And no doubt, when they saw this beer record, they made some change in their habits. Still this is not stated.

From the knowledge we already have of the power of alcohol over the cell, we are not surprised to hear that the beer-drinking children were handicapped from the start. They were not to blame, surely, for they used the beer through ignorance. In all probability their parents were not to blame either, for multitudes of even middle-aged people have not as yet heard of these recent scientific discoveries about the effect of alcohol on living cells. For us, however, the record simply proves that

alcohol hampers children no less than it hampers automobile drivers, typesetters, dogs, jellyfish, and the water flea.

Nevertheless, the most recent charge against alcohol is not simply that, by using it, men and children weaken their own cells, but that very often there is close connection between the drinking habits of parents and the failure of the minds of their children.

Dr. Howe was once asked to study the life history of those children in Massachusetts who have no minds — idiots we call them. He did the work thoroughly, became acquainted with the history of three hundred of these deplorably unfortunate young people, and discovered that one hundred and forty-five of them were the children of drunkards.

In his book called *American Charities*, Dr. Warner gives the case of a family in which the older children had strong bodies and strong minds, while three of the younger children were complete idiots and the fourth was defective in his mind. It seems that before the first children were born the father was a temperate man, that little by little he became intemperate, and that his last four children were born during the time that he was a drunkard.

Dr. Warner also speaks about idiocy in Norway. He says that in 1825 the tax on spirits was removed. This, of course, made it possible for multitudes of people to

indulge in the luxury of alcoholic drinks, who had never been able to afford it before. Perhaps they rejoiced as they did their drinking. The result, however, was an awful curse to very many children who were born in the land after that; for during the first ten years after the tax was removed, the number of idiots born in Norway increased one hundred and fifty per cent. In addition, insanity itself was increased fifty per cent.

Professor Demme in Berne, Switzerland, looked up the intimate history of ten families who drank and of ten families who did not drink, and the record which those parents were making for their children reads now like a page torn from the book of a judgment day.

RECORD OF TEN DRINKING AND TEN ABSTAINING FAMILIES

	Number of Children	Died in Infancy	Idiotic, Epileptic, Misshapen, or Serious Nervous Trouble	Normal
Drinking families .	57	12	36	9
Abstaining families	61	5	6	50

Thus far we have been considering the records of the lives of such men as have become drunkards. The great multitudes of those who use alcohol, however, never arrive at this extreme.

I have in mind a certain policeman in New York City. He was talking to a friend of mine, and when the subject of alcohol was reached, he said: "As for

myself, I confess I do drink a little once in a while. You see I began when I was young and didn't know better. And now I sometimes think I can't stop. That's the trouble with alcohol you know. The habit creeps over you slowly and there you are. You can't stop even when you want to."

"And what about your boys?" my friend asked. She knew about his six fine sons, and she knew how proud he was of every one of them.

"That's it," he said. "There are those boys of mine—three of them in the high school and three in the grammar school, and every one of them high up in his class." He stopped, looked very serious, hesitated for a moment, then went on in a solemn tone and in a low voice: "I've never let those boys of mine see me take a drop. The fact is they don't believe in alcohol. Their mother's taught them that way. That's the sort of mother she is—a fine woman with never a cross word for any of us." And he straightened himself up rather proudly as if from great respect for his wife and his boys.

In talking about it afterwards, my friend said: "It almost frightens me to think of that man. The habit is certainly growing on him. His breath indicates clearly what the end may be. Then what about those boys and that wife of his?" We said little after that, because we both knew what danger the man was running, both for himself and for those who were dearest to him.

Fortunately for the towns and cities and countries of the world, the number of their drunkards is limited. But science has recently brought to light some facts which are a surprise to most of us — facts which will probably result in a change of habit in a good many families.

In his book called *Alcohol and the Human Body*, Sir Victor Horsley reports a piece of work which was done by Dr. MacNicholl for the New York Academy of Medicine in 1901.

The members of the Academy wished to know whether or not it is possible for a man to damage his own cells in such a way that the children who spring from those cells afterwards will be less vigorous in mind and body than they otherwise might have been.

No guesses or theories can answer so searching a question as this. Indeed, nothing can be convincing except close study of facts carried through successive generations of families, covering long stretches of time; for facts and not theories answer our questions for us nowadays.

For the sake of doing thorough work, Dr. MacNicholl and those who helped him looked into the life history of 55,000 school children. Of these, 10,800 belonged to country schools, 44,200 to city schools, and the total number of schools from which the entire number of pupils came was 143.

Of this vast number of children he now took 20,147 and learned about the drinking and the nondrinking habits of their parents. The result was as follows:

DRINKING HABITS OF PARENTS OF 20,147 CHILDREN

Number of those whose parents used alcohol sometimes . . .	6,624
Number of those whose parents never used alcohol	13,523

Dr. MacNicholl then looked into the school records of the two groups, and perhaps he was astonished at what he found. I give his discoveries as concisely as possible.

CHILDREN DULLED BY DRINKING PARENTS	Dullards
Children of those who drank (out of every hundred)	53
Children of those who did not drink (out of every hundred) . .	10

The doctor's remark about these surprising figures is: "The close correspondence between the drinking habits of the parent and the mental deficiency of the child cannot result from mere accident." He therefore accepted the conclusion that, in an enormous number of cases, parents who drink damage the working power of the brains of their children.

And now he wished to know whether or not the same mischief can be carried down the race through two generations of people.

For this investigation he took 3711 children who belonged to 1100 different families, and gathered facts about the drinking habits of all their parents and grandparents. He divided them into the following groups:

children of drinking parents; children of drinking grandparents; children of drinking parents and grandparents; children of abstaining parents; children of abstaining parents and grandparents. Most of those parents or grandparents who used alcohol were moderate drinkers.

After he had in this way separated the children according to the drinking habits of those who started them in life, Dr. MacNicholl turned to the teachers and to the school records of these same children and found the following rather startling facts.

CHILDREN WITH AND WITHOUT INHERITED TAINT OF ALCOHOL

	Proficient	Dullards	Had Nervous or other Disease
With alcoholic inheritance (in every hundred)	23	77	76
Without alcoholic inheritance (in every hundred)	96	4	18

Dr. MacNicholl is still carrying on his investigations, and it may be that finally his conclusions will be changed somewhat.[1] Nevertheless, in view of what he finds, and

[1] The investigations by Dr. MacNicholl include a study of a larger number of cases than have ever been similarly studied. The investigation itself is an exceedingly complex one, extending to the parents and grandparents of several thousand persons. The value of such a study rests largely on the competency of the investigators and the judicious selection of methods. Inasmuch as the study is as yet incomplete, the facts cannot be secured which would enable one to judge of the value of the work from these standpoints. Still the work itself is so important as to render it impossible to ignore it; accordingly the chief conclusions are given. — LUTHER HALSEY GULICK, Editor.

in view of the other facts given in this chapter, we are safe in concluding that when men and women consent to use alcohol as a drink, their greatest unkindness is not against the cells of their own bodies, but against the cells of their children and their grandchildren after them. For the charge is not so much that alcohol has the power to turn kind men into fiends, to ruin the healthy bodies of those who drink it, to carry devastation and death into tens of thousands of homes in every land — although all this history of facts makes an awful record; but the graver charge of this chapter is that alcohol used by one generation curses and blights other generations yet unborn, and compels them to be what otherwise they might not have been.

As a rule, harm of this sort is done through ignorance alone. Those who drink moderately do not know that the bit of protoplasm which starts the life of another is far more sensitive to injury by alcohol than the body of a grown man, and that it may be so affected that it will develop into a human being who has been robbed of his birthright.

This does not mean that the children of those who drink are necessarily doomed; but it does mean that they must give the more diligent heed to every known law of general health and nerve health. They must do what they can to undo their inheritance and thus, in so far as possible, to balance the account in their favor.

The lesson of this chapter is that we should so guard the cells of our bodies from harm of every sort that our children and our children's children after us will bless us and not curse us for the quality of the living cells which we have handed down to them. In the past, ignorance has been the reasonable excuse for much harm that has been sent on through the generations from father and mother to son and daughter. Henceforth, however, this ignorance ceases to be a shelter for those of us who have learned to read and to think and who are bright enough to follow the record of modern scientific discoveries.

CHAPTER XXX

POWER THROUGH SUGGESTION

Notice a sensible mother whose small son has just bumped his head. Does she cry out, "Oh my precious boy! Oh how it hurts! Poor head! Poor little fellow!" By no means. Instead she uses a cheery, matter-of-fact, encouraging tone of voice, and says: "Well, well, that was too bad. But I'll cure you in no time." Then she hands him top, ball, picture book, or rattle, and talks to him of other things while she does what is necessary with water and bandages.

Her one object is to turn the child's mind away from his injury; for she knows that pain actually increases according as our mind is fastened on it, and decreases according as it is removed from it.

A butcher once proved this fact for himself. I give the account as Dr. Carpenter himself quotes it:

> A butcher was brought into the shop of Mr. Macfarlan, the druggist, from the market place opposite, laboring under a terrible accident. The man, on trying to hook up a heavy piece of meat above his head, slipped, and the sharp hook penetrated his arm, so that he himself was suspended. On being examined, he was pale, almost pulseless, and

expressed himself as suffering acute agony. The arm could not be moved without causing excessive pain, and in cutting off the sleeve he frequently cried out; yet when the arm was exposed it was found to be quite uninjured, the hook having only traversed the sleeve of his coat.

The man's thought about what had happened was evidently quite enough to plunge him into agony. It is knowledge of this law of the mind that leads a sensible mother to treat her children wisely. She knows that, in any case of slight injury, one of three things may be done.

1. She may soothe and pet and coddle the child. The disadvantage here is that this draws the child's attention all the more to his own woe and increases his pain.

2. She may scold the child for crying, call him a coward, and tell him to be brave. But even a little child will feel that this is unkind and unjust.

3. She may divert his attention by getting him to notice something else. This is the one sensible way to manage, for the pain will be decreasing while his mind wanders from it.

A man whom I know shows what suggestion will do in another direction. He has a very straight back. When I referred to it once he laughed and said: "That comes from accidental eavesdropping when I was about eight years old. I passed the parlor door and heard a lady say to my mother, 'What a straight back your little son has!'

Probably she didn't know what else to say, for I was a homely little scrap. But I stiffened up on the instant and walked off like a major general on dress parade. Sometimes, even now, people tell me I walk as if I were proud, but it all comes from that casual remark of a casual caller. It gave me the suggestion that a straight back is worth while."

I thought about the talk afterwards and came to the conclusion that the mere fact of walking like a soldier had also been a suggestion that had helped him in other ways. It had increased his self-respect, his courage, his willingness to do hard things, his unwillingness to be mean and sly and deceitful. In other words, the fact that he walked like a soldier had inspired him to become all that a gallant soldier is supposed to be.

In every town there are boys who treat their neurons as wisely as a mother treats her baby. They act as if they understood these hidden laws of the mind perfectly. They are hit hard by accident; they may be so wounded that I am sure they might be expected to cry out with pain, but they give little heed to cut or wound. They say, "Oh pshaw! It doesn't hurt! What's the use of making such a fuss?" They also divert their own minds by turning to something else, and by this scientific way of enduring their pain they lessen their feeling of it.

There is, of course, such a thing as carrying all this too far. Wounds and bruises should be attended to, not

ignored. But the one point made here is that if the mind is diverted there will be less suffering.

He is a dull thinker who does not spring to a sudden conclusion just here. He says to himself: "If I can jolt my neurons away from pain by the power of suggestion, why can't I jolt them into serving me in other ways by the same power?" Certainly you can. This is often done.

I knew nothing about these laws when I learned to ride the bicycle. As a result I made droll mistakes and learned slowly.

Why was it that at first I always ran into the telegraph poles which I was most anxious to avoid? Probably because I worked according to the negative and not according to the positive plan. I was ignorant. I thought that if I told myself firmly not to run into certain poles, I might escape them. The truth, however, was that by fastening the power of my neurons on the pole they seemed to take the matter into their own hands, compelling my unwilling hands to steer the wheel towards it. I should not have looked at the pole. I should have banished it from my mind. I should have kept my eye on the road ahead. Instead of saying to myself, "Don't run into it," I should have said, "Keep to the road."

Success usually lies in the direction of positive and not of negative commands. In other words, let our minds dwell on the things we must do, not on those we must not do.

I sometimes think that the whole of life is a case of positives and negatives. One man says, "I must not fail"; another says, "I will succeed." And the latter is on the straightest road to his goal. One woman thinks, "I won't be irritable"; another thinks, "I will be cheerful." And the home of the latter turns out to be the more cheerful place of the two. One child says, "I want friends; I mustn't be cross and disagreeable." Another says, "I want friends; I'm determined to be pleasant and agreeable"; and she it is who wins friends the faster.

A wise student never tells himself not to forget when he comes to this place or that in oration, examination, or piece of music. Instead, he says, "Just at that spot I'm determined to remember." Travel through life under the positive flag, and your goal, whatever it is, will be the more surely and swiftly reached.

As to getting the best possible help from our neurons for all this, one way is to make suggestions to them before falling off to sleep. A friend of mine told me this when I was studying the Japanese language years ago. "I've found out how to learn words fast," he said one day. "How?" I asked. "It's very simple," he said. "I take the list of a dozen words, or so, and, without studying hard at it, read it through slowly and carefully just as I get into bed at night. And I am astonished to see how nearly learned the words are by morning. It

seems as if my mind does something special with them while I sleep."

All this was news to me at the time, but since then I have learned that many people practice the same plan when they wish to make definite progress in any chosen line. Try it for yourself. If you wish to be cheerful and courageous to-morrow, put the matter in charge of your neurons to-night. As you go to sleep, think to yourself: "I'm cheerful and brave. I'm cheerful and brave." And keep on thinking these words to yourself until you fall asleep. By persisting in this method you will give yourself a big lift towards the thing you wish.

Never let yourself fall asleep with anger, or worry, or fear, or hatred in mind; for each emotion of this kind will be caught up by the wonder-working neurons, and conditions will be worse and not better when you waken in the morning.

Before each night of sleep make it the rule of life to enlist the help of your neurons for one high thought or another, and you will secure a happy life for yourself—a life which will also be a help to others.

This power of suggestion explains what some people can do in the way of waking when they please. A boy whom I know does this. As he falls asleep he tells himself when to waken, and behold, when the hour comes round he finds himself awake. More than this, when his older brother, in the same room, is to get up by an alarm

clock, the younger one, as he falls asleep, tells himself not to hear the alarm. His brain obeys, and, as he sleeps on, the entire rattle and clatter disturbs him no more than the gentle patter of raindrops on the roof. This is a rare power.

Doctors practice suggestion in a more usual way. Notice the words and the actions of any good physician. He is constantly giving the man who is ill the notion that he will soon be better. A friend of mine takes pride in believing that he cures quite as much by his suggestions as by his medicines. He says that the man who is ill and expects to get well has ten times the chance of the man who is ill and expects to die.

It is evident, then, that we may even help ourselves towards health or towards death by the power of our expectation, for this is the strongest kind of suggestion.

But what about unconscious suggestions which human beings give and receive on every side? Three bits of conversation which I stumbled on the other day show what I mean.

The first man said: "I told him it would be the very place for Clarence, provided James Smith were not there; but to throw a young fellow like Clarence into the constant companionship of James would be a frightful calamity. It would probably ruin him for life."

The second man said: "I am as anxious as possible to have my son get acquainted with Harvey Jones. It may change the current of his whole life."

A woman said, "We think we can always tell where Mabel has been because she comes back with the manners of the last person she has visited."

Of one boy we say, "He may be trusted anywhere"; of another, "He will do pretty well so long as he is with the right sort of companions, but you have to keep him there to make sure of him."

Facts like these, met with all about us, prove the power there is in suggestion even when it is given out unconsciously. But the special fact to bear in mind is that each separate suggestion, however unconsciously made, leaves its individual mark. Moreover, through these suggestions which we receive from others or give to ourselves, we form habits of thought; through habits of thought we form habits of character, and through habits of character we finally become so fixed that change is practically out of the question.

It is evident, therefore, that no one stands alone, and that we help or hinder each other through the character which we ourselves have, through the unconscious suggestions which radiate from us wherever we go. For, as some one has said, "influence follows character as the shadow follows the sun." Clearly, then, we never influence others according to what we wish people to think we are, but according to what we really are.

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QUESTIONS

Chapter I

What happens to the spinal cord when the vertebræ are crushed? How does pressure on the spinal cord affect the rest of the body? Give an illustration. What occurs when pressure is lifted from the cord? Give illustration of loss of sensation. What is at fault when the body fails to move, or to feel, or to do its work? What is the work of nerve fibers? What do these fibers look like? Where are they? Of what do they remind us? Of what use are pleasant and unpleasant sensations? If animals lacked sensations what would be the result? Name some of our most valuable sensations.

Chapter II

Give the case of the British captain who was hit on the head by a bullet. Why was he unconscious? What relieved him? Where is the cerebrum located? What does it do? What are its two divisions called? How does a frog act when his cerebrum is injured? What does a pigeon do when his cerebrum is injured? Tell of the dog with an injured cerebrum. What does the brain look like? Mention its two important divisions. Describe their location; their appearance; their color. What is the value of the creases and wrinkles? Where is the gray substance? How thick is the gray layer? What are some of the effects of injury to the gray substance? What is this gray layer called? How is the brain protected? What separates the brain from the skull?

Chapter III

Who studied Margherita's brain? Describe Dr. Mosso's machine. What record did it make when Margherita was frightened? What did this prove? What happened to Bertino? How was his brain studied? When were the pulse lines of the record low and broad? When sharper and higher? Mention some of the tests that Dr. Mosso made while Bertino slept. How did noise affect the record? What did this higher mark prove? What happened when Dr. Mosso spoke severely to Bertino? Mention four lessons taught by these experiments. Why do we need quiet when we sleep? Why are people trying to be rid of noises at night? Describe a balance board. What may cause the balance to change from time to time? Why are hands and feet cold during fright? What nourishes the brain? How may the value of blood be increased?

Chapter IV

What is the ergograph? Describe it. What did Dr. Mosso wish to discover by its use? Name the friends who helped him. When were the tests made? Through how many years were they continued? What did the "fatigue curve" always prove about the one who used the ergograph? What effect did a hard examination have on Dr. Maggiora's power to pull the weight? What was the effect of three days of rest? Give the first great lesson of fatigue. In order to do good muscular work what must be the condition of both body and mind? If the brain is overtired what kind of work will the muscles do? What connection might there be between a boat race and a hard examination? After such an examination what sort of exercise is best? Is hard thinking wholesome or unwholesome for the brain? What is the sign of overwork?

Chapter V

How did Dr. Mosso study the effect of tired muscles on the power of the brain? Describe the flight of the quails from Africa to Italy.

How did the birds show they were tired? Describe Dr. Mosso's carrier pigeons. How were they trained? What leads a carrier pigeon to fly homeward? How far did these birds fly? Where did Dr. Mosso watch for their coming? How did the younger ones show their exhaustion? What parts of the body did Dr. Mosso examine? How did their wing muscles look? What was the condition of their brains? What, then, explained the failure of eyesight of the African quails? Describe a certain bicycle race and the failure to see clearly. What was the explanation? When a man wishes to do good work with his brain how should he arrange about muscular work? How sensible would it be to try to pass an examination after a boat race? Give the second great lesson of fatigue. What is the test of being overtired? In what way does cumulative fatigue do harm?

Chapter VI

Where is the amœba found? When studied through the microscope what does it look like? How does it change shape, and travel? What is its substance? Why is protoplasm important? How does the amœba get food? Describe the way it multiplies. What three rules does the amœba live by? How does sensation travel across the protoplasm of the amœba? Why are scientists interested in the amœba? Does the amœba belong to the single-celled or to the many-celled group of animals? What is the difference between the two groups? Describe a single-celled animal.

Chapter VII

Describe the appearance of an amphioxus. Where does it live and how does it secure food? How does it differ from the amœba? What part of the amphioxus proves that it is related to man? Where is the nerve tube? How large is a full-grown amphioxus? How many cells are there to the egg of an amphioxus? In what way is every egg like

an amœba? Describe what goes on within an egg as the animal develops there. What is the difference between this process and the multiplying of any single-celled creature? While the cells are multiplying within the egg how do they arrange themselves? How many layers of cells are there? What part of the body does the outside layer become? the middle layer? the inside layer? Why are we specially interested in the nervous system of the amphioxus? Why does a many-celled animal need a nervous system?

Chapter VIII

Describe Dr. Richardson's experiment with jellyfish. What lesson did it teach? What proportion of alcohol to water will kill the water flea? Describe the experiment with cress plants. What effect has alcohol on the life and health of chickens? Who were Bum and Tipsy, Nig and Topsy? Describe Dr. Hodge's experiments with them. What were the gymnasium tests and what did they prove? On whom did Professor Kraepelin make his alcohol tests? Describe the experiment. What effect did alcohol have on the power of the men to add figures? Tell what you can about the experiments with typesetters. How much alcohol did the men receive and when did they drink it? What did the results prove? What did the men think about their own work before and after they used alcohol? Describe the experiments with soldiers in Sweden. How much alcohol was given and when? What effect did it have on the shooting? What does Sir Frederick Treves say about the soldiers who marched to Ladysmith? What is the teaching of this chapter about the effect of alcohol on nerve cells?

Chapter IX

If the entire nervous system could be separated from the body and could be set up stiff and firm, what would it show? If the figure could be cut open where should we find large clusters of nerves? What was

the ancient notion about nerves? What has the microscope revealed about them? In what way is a nerve cell like an amœba? What becomes of the slender arms of the nerve cell? What is the white thread that we call a nerve? What is the difference between a large nerve and a small nerve? What is the substance of a nerve cell? Describe the arms of a nerve cell. What is the difference between axon and dendrite? How many axons may a cell have? What is the scientific name for a nerve cell? Mention the three parts of the neuron.

Chapter X

Mention one great difference between amœba and neuron. Where are the cell bodies of the neurons located? What is a ganglion? In what two ways is a cluster of nerve cells like a telegraph station? What is the vital part of each neuron? In how many directions can any one axon carry messages? How many vertebræ are in the human backbone? How many round openings are there between the vertebræ? What passes through these openings? How is each spinal nerve joined to the spinal cord? What is the difference in appearance of the two roots? What explains the swollen look of one root? On which root do the upward-going messages travel? On which root do messages travel from the brain to the body? How often do messages lose their way? Explain the gray and white substance of the brain. Which part is made up of cell bodies and which of axons? What is the work of axons in the brain? What difference is there in the arrangement of the gray and the white in the brain and in the spinal cord? Without the microscope what do the brain and spinal cord look like?

Chapter XI

Describe the work of different sets of fibers as a baby puts his finger into the flame and pulls it out again. Describe the work of central neurons. In what way do they seem to carry on a relay race? What is

the relation of the tip ends of the dendrites and axons of different neurons to each other? How long may the longest axon be? If we had eyes and instruments keen enough, what discoveries would we make about the intertwining of the axon fibers? Which are the largest nerve bundles in the body? How many fibers do they hold? What is the result when axons are cut across and separated from their cell bodies? If the smooth spinal root is cut, what is lost — motion or sensation? If the ganglion root is cut which power is lost? If both roots are cut what is the result? How could the old soldier suffer pain in his heel when his leg was cut off at the knee? How did he secure relief from his suffering? What effect did his knowledge of his condition have on the axons which sent reports to the brain?

CHAPTER XII

What did Dr. Flourens discover about the cerebellum of a pigeon? What do scientists think the cerebellum is for? How do they explain our power to do things even after years of no practice? Mention directions in which this memory of the cerebellum is useful to us. How may neurons be taught lessons? Describe the freshman who was giving himself a straight back. In teaching neurons, when may we feel encouraged? Mention some special ways in which they should be trained. How are neurons sometimes trained without any plan of ours? In what ways do face muscles declare facts about us? In this respect what difference is there between muscles of the face and large muscles of the body? Why does an old face tell more about character than a young face? Was the training of the neurons consciously or unconsciously given? What is the fact about neurons and muscular work? What is the fact about neurons that learn lessons and tell the truth? How may we compel our neurons to declare that we are courageous, kind, and sincere? If a man pretends he has good qualities when he lacks them, what will be the result?

Chapter XIII

What is the phagocyte? What does its name mean? Describe the experiment of cholera microbes, the frog, and the phagocytes. In what ways is the phagocyte like the amœba? Why does a frog never die of cholera? Why do pigeons never have tuberculosis? Describe the action of phagocytes in the body. If intruding disease microbes are more numerous or more vigorous than our phagocytes, what happens to us? If a man or child yields quickly to a disease, what does this prove about his phagocytes? If he is able to resist disease, what is it that has saved him? What does the phagocyte do in case we are cut or wounded? What is pus? What difference may there be in the healing of the wounds of two men in a hospital?

Chapter XIV

What should be our daily command about phagocytes? What connection is there between health laws and the vigor of the phagocyte? Speak of what happened in Glasgow in 1848. How do you explain the connection between the death rate and the drinking of alcohol? Tell about the boy and the man bitten by the mad dog. What experiments did Dr. Delearde make on the rabbits? How did he explain results? Why did Bum and Tipsy suffer more from the epidemic than Nig and Topsy? Which does the most harm in the body, disease microbes themselves or the toxin they produce? In what way do phagocytes protect the neurons? In a case of pneumonia, why does a doctor take courage when phagocytes increase their numbers? Where does he look for the phagocytes? What occurs when a phagocyte finds itself in blood that holds a trace of alcohol? When phagocytes are overcome by alcohol, what is the outlook for disease microbes in that body? When a man drinks to the health of his friend, to whose success and to whose death is he really drinking? Why should we protect the phagocytes from harm?

CHAPTER XV

Why did Dr. Hodge choose the sparrow for his cell investigations? What did he wish to discover? What did he learn about the condition of the cells in the morning and in the evening? After the birds had spent a day in "scolding and chattering," where were the tired cells found? In the swallow, why should cells in the cerebellum have been most changed? In which part of the cell was the greatest change? What testimony came from the brains of bees? How does a cell and its nucleus look before exertion? What change does great exertion produce? What helps the cell to grow plump again? Is it the cell body or the fiber of the neuron that grows tired? When is fatigue good for us?

CHAPTER XVI

Mention different ways of resting. What is "lomi-lomi"? How does a tired person feel after being "lomied"? When muscles are exercised what harm does the broken-down, waste material do to the body? When blood from a tired animal is put into a rested animal what is the result? What does toxin of fatigue mean? In what way does massage help the body to get rid of its fatigue poison? What tests did Dr. Maggiora make with massaged and unmassaged fingers? What did the ergograph prove? After a ten-mile walk how quickly did massage help him to give the normal pull again? Why do athletic trainers advocate the use of massage? What effect did massage have after a sleepless night and a feeble pull? Give three reasons why massage helps the neurons. In what way does the toxin of fatigue help protect the neurons? What two things does rest do for us? *Answer.* It gives the body a chance to rid itself of the toxin of fatigue and it gives the nuclei time to grow plump again.

CHAPTER XVII

When neurons are tired how do people sometimes show it? What does crossness often prove? How may we get rid of it? What did

Senator La Follette discover about the connection between sleep and railroad accidents? Mention one or two of the cases. How much can overtaxed neurons be trusted? Why do we grow sleepy when the brain does not exert itself? What connection is there between sleep and blood in the brain? How may a sleepy feeling be driven away? When people cannot sleep what is the condition of the brain? Give some rules for securing sleep by drawing blood from the brain. Why does quiet and monotony help? What sets of neurons do not stop work even when we sleep? What may sleep be called? Why do we treat the neurons well at night? What people need the most sleep? How can we tell whether we are sleeping and resting enough? If a man wakens tired day after day, what risk does he run?

Chapter XVIII

Why did the boy faint at the end of the race? In what way did the muscles rob the brain of blood? How may a man prepare himself not to faint? How does a bicycle rider overwork his heart? How may the heart beat be controlled? What is the work of the sympathetic nervous system? How many ganglia unite to form it? Where are they and how are they joined to each other? Where do the axons from the ganglia go? What is a plexus? Where are two that are very important? How are the sympathetic ganglia connected with the spinal cord?

Chapter XIX

How may the heart be forced to beat faster? What does such a test prove about the power of one set of neurons to govern another set? How can we compel salivary glands to go to work? How can we force gastric glands to manufacture gastric juice? Give the case of the woman who suffered because the baby's fingers were crushed. State the explanation. How did cats prove that feelings affect the work of the stomach? Describe the experience of a boy in the same direction.

Tell about the motto and the actions of the happy family. Describe the unhappy family. Give four scientific reasons why happiness helps the body. What special things help us through the sympathetic ganglia? Why are lessons learned faster and recited better when we are happy than when we are unhappy? Mention certain conditions that may interfere with the best work of the human machine. Mention ways by which we may get good service from the sympathetic ganglia. What may we do to turn off feelings that harm the neurons, and to turn on feelings that will help them to help the body? Describe the process step by step through one day. When a person is able to wring victory out of a day that started wrong, what does he thus prove about his own character?

CHAPTER XX

What is proved when a boy leaves his bed and goes fishing at four o'clock in the morning? Describe the imaginary case of two hunters. In what ways do different people take pleasure as they live from day to day? What do some people do about small present pleasures and large future pleasures? What reports came from Africa about cigarette-smoking soldiers? What was the result when American boys were examined by a naval officer? Why does General Wingate advise against cigarettes? Mention some of the ways in which cigarette smoke damages the body. In a few words tell what Judge Stubbs thinks about the effects of cigarettes on the character of boys. How does smoke do its harmful work? What special parts of the body suffer from the poison? What is the special reason against using a few occasional cigarettes? What are business men doing about employing those who use cigarettes? Mention a few cases. Describe the two classes of people who use cigarettes.

CHAPTER XXI

Tell what you can of Jemmy Morgan. How did he act after he could see? Speak of the older boy whom Dr. Carpenter describes. How did

his sense of touch help his eyesight? How did the baby with the hot potato show that touch has to be trained? Who was Laura Bridgman? What was her condition until she was eight years old? What was her condition after that? Describe her education. Mention some of her fine traits of character. How may we train our senses? How do the Australians train their eyesight? How keen a sense of smell have the Indians in Peru? What connection is there between close attention and trained senses?

Chapter XXII

How fast does stimulus from the skin travel to the brain? Where do we suffer when a finger is burned or a foot is crushed? What happens to the cells in the brain when the stimulus reaches them? Name the five great nerve roads that lead to the brain. When you think of chocolate creams what sets of neurons give their reports? In what way may we help ourselves to understand and remember things? Contrast Laura Bridgman's notion of a rose and your notion of a rose. Why do lecturers use the stereopticon when they talk? Why do teachers use the blackboard? Mention the three parts of each sense machine. Which part of the apparatus resembles the mouthpiece of a telephone? Which part of the machine feels our sensations for us? What discoveries do men make who examine the brain after death? What did Laura Bridgman's brain show? If the outside apparatus is damaged what can we do? If one sense is wrecked what must be done about the other senses? How can the cortex be thickened?

Chapter XXIII

How do bodies grow larger? Which cells make little increase in number after birth? Since the number of our neurons does not change, how can we increase our wisdom and our skill? What may be the greatest difference between two brains? How are the different parts of the brain connected with each other? How do the messages travel

from cell to cell? How may we increase our ability in any direction? What is the rule about increasing the number of the paths between the neurons? In any particular case how can we know whether or not neuron connections have been made? During what time of life are connections most easily and surely made? Think of cases that prove this. Why can't we teach old dogs new tricks? In what way may any boy or girl become that which he desires to be? When a man succeeds, what does he prove about his dendrites? What connection is there between luck and the dendrites? Which is better, to have more neurons with fewer paths between them, or fewer neurons with many more paths between them? Why is it so important that the connections we approve of should be made when we are young?

CHAPTER XXIV

Describe the testing of the crab in the maze. What did the test prove? Describe the test of the crab and the screen. How did the chick prove that he too learned from experience? What is it about neurons that explains memory? When a creature learns by experience what do we decide about his intelligence? How do we feel towards those who will not learn by experience? What relation is there between experience, choice, and habit? Which student gains most, he who studies for high marks or he who studies to understand the subject? Give two reasons against cramming. Why is that which is learned easily, forgotten easily? Besides connecting neurons with each other, how do we mark them? Tell about the young woman whose neurons had been marked by Greek and Hebrew sounds. Give several rules for remembering. Why do we wish to increase connections between the neurons? What is the secret of learning history? Describe the best way to memorize poetry or prose. Why do "bridges" help? As promptly as possible memorize something in the sensible scientific way. Do what you can with bridges in your history and literature topics.

Chapter XXV

Tell about Buster and his moral victory. Give the case of the man who trained monkeys to be actors. What was the fate of monkeys who showed no power of attention? In what two ways are human beings superior to monkeys? Tell what you can of Robert Houdin and his son. What great lesson do we learn from such cases? Describe the two boys in the schoolroom. Why did the teacher think one of the boys might never amount to much? Through what power did the other boy learn his lessons quickly? What experiment proves that noise prevents the neuron from doing its quickest work? Why should the schoolroom be quiet? Why do teachers put hard lessons early in the day? Why do they sandwich hard and easy lessons between each other? What good does attention do in a race? In every part of life, what connection is there between attention and success? Tell what you can about the way in which character gets its final shape. In what ways do we show what we are?

Chapter XXVI

What was the great prohibition in China in 1907? How does the man look who is destroying himself with opium? What effect does opium have on character? Why are doctors careful never to give a dose of it unless it is absolutely necessary? Mention some of the crimes that alcohol leads a man into. Describe the difference in appearance between normal nerve cells and cells diseased by alcohol. What special effect does alcohol have on the dendrites? Why is it specially harmful to have useless dendrites? When the connections between the neurons are weakened by alcohol, what is the effect on the character of the man? When neurons are diseased by alcohol, what special thing do they call for most earnestly? How easy is it for the man who is forming the alcoholic habit to recognize his danger? How easy is it for him to break the habit?

Chapter XXVII

What was the history of the man whose foot dragged? What is the lesson of this story? Mention some of the ways in which people betray themselves unconsciously. Why does Professor James call us "bundles of habits"? How do the bones and muscles of the back get the habits which give an old person a bent back? In what way might the same bones and muscles form other habits? Who is responsible for your habits and mine? How is any habit formed? Why have we a right to judge each other by our habits? Give the case of the man who was unfortunate because of his eating habits. Mention some small habit which may be hard to overcome.

Chapter XXVIII

Mention some ways in which it is an advantage to do things by routine. How do habits of dressing save time? If neurons never learned lessons and formed habits, what would be the result? What is meant here by freedom and slavery? In what two ways are habits formed? Give an instance of a habit formed in an instant which continued for years. When may knowledge be a help in forming habits? State a few contrasting habits of character. Pick out your own habits from the list and decide whether or not any change is desirable. Give in a nutshell the three great laws by the use of which we may start new habits. Give what you can of Professor James's thoughts which close the chapter.

Chapter XXIX

What investigations did Dr. Bayer make in Vienna? What connection did he find between dull students and drinking beer? (Do not try to remember the exact figures.) Why were the children not to blame? What did Dr. Howe learn about idiots in Massachusetts? Describe the family mentioned by Dr. Warner. What happened in Norway when the tax on spirits was removed? What did Professor Demme learn about

ten drinking and ten nondrinking families? (Do not try to learn the exact figures.) Tell about the policeman in New York City. What did Dr. MacNicholl wish to discover for the Academy of Medicine? How many school children were studied? Why did he look into the drinking and the nondrinking habits of the parents of over 20,000 children? How many dull children were there in each hundred of those that belonged to the two groups of parents? What special study did he give to the parents and grandparents of 3711 children? What was his discovery about the children and the grandchildren of those who had used alcohol? What, then, is the most serious charge against alcohol?

CHAPTER XXX

When a small child hurts himself what should be done? Describe the accident to the butcher. Why did he suffer? Tell about the man and his straight back. What suggestions do wise people make to their own neurons when they hurt themselves? What is the difference between positive and negative commands? Which kind makes the best suggestion to the neurons? Give illustrations to prove this. What suggestions are helpful as we fall asleep at night? What can suggestions do in helping us sleep and in waking us at stated times? How may a doctor do his best work? How may we influence ourselves towards health when we are ill? What can you say about unconscious suggestions? When do we make them? In what way are suggestion and habit related to each other? In what way are we always sure to influence others?

GLOSSARY

Key: fāte, senāte, făt, ärm, all, ȧsk; mēte, ēvent, mĕt, hẽr; īce, ĭdea, ĭt; ōld, ōbey, nŏt, sȯn, hôrse; ūse, ūnite, ŭp; babȳ; au *as in* author; c *as in* call; ç *as in* mice; g *as in* go; ġ *as in* cage; n̲ *as in* ink; ph *as in* phantom; ş *as in* is; ti *as in* motion; obscure sounds: a̤, e̤, i̤, o̤, etc. Silent letters are italicized.

ȧ mœ̄'bȧ, a microscopic creature consisting of a single cell of protoplasm.

ăm phĭ ŏx'ŭs, the simplest vertebrate animal.

är'dū *o*ŭs, hard, difficult.

ăs sō'cĭ ā tĭv*e*, tending to unite or associate.

ăx'ŏn, the longest and straightest branch of a nerve cell.

bȧ çĭl'lŭs (*pl.* bacilli), a microscopic organism, different kinds of which are believed to be the cause of various diseases.

çĕr ē bĕl'*l*ŭm, a division of the brain situated at the back of the head below the cerebrum or main division.

çĕr'ē brŭm, the upper and larger division of the brain.

cō ôr'dĭ nāt*e*, to make work together in harmony.

côr'pŭs çl*e*, a minute particle of matter.

côr'tĕx, the layer of gray matter covering the surface of the brain.

cū'mū lā tĭv*e*, increasing by successive additions.

dĕn'drīt*e*, the name given to an arm of a nerve cell which branches like the twigs of a tree.

dȳs pĕp'sĭ ȧ, impaired power of digestion.

ĕn ġĕn'dẽr, to produce; cause.

ẽr'gō grȧph, a machine for testing the muscular strength of the fingers.

flŭc tū ā'tion, a motion like that of waves.

găn̲'glĭ ŏn (*pl.* ganglia), a collection of nerve cells.

găs'trĭc, belonging or pertaining to the stomach.

ĭm prŏmp'tū, without previous study or preparation.
ĭn ē'brĭ āte, a habitual drunkard.
ĭn tẽr mĭt'tent, ceasing at intervals.

lȳmph, a fluid in animal bodies contained in certain vessels called lymphatics.

măs tĭ cā'tion, the act of chewing.
mī'crōbe, a microscopic organism; a germ.
mŏl'ĕ cūle, the smallest mass of any substance capable of existing in a separate form.

neū'rŏn, the name given to a nerve cell considered as a whole.
nĭc'ō tĭne, the poisonous element of tobacco.
nôr'mal, natural; regular.
nū'clē ŭs, a kernel; the central mass or point about which matter is gathered.

ō'ral, spoken, not written.
ôr'gan ĭşm, a structure composed of organs.

phăg'ō çȳte, a white blood corpuscle.
plau'dĭt, an expression of applause.
plĕx'ŭs, a network.
prō'tō plăşm, the material in cells which furnishes the beginning of nutrition and growth in animal and vegetable organisms.

sĕd'ĭ ment, matter which settles to the bottom of any liquid.

tŏx'ĭn, the poison produced by disease microbes.
tū bẽr cū lō'sĭs, a disease characterized by the formation of tubercles in various tissues of the body.

văc'ū ō lā tĕd, having small cells or cavities.
vẽr'tē brāte, an animal having a spinal column.

INDEX

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